A

DICTIONARY

OF

CHEMISTRY.

CONTAINING THE

THEORY and PRACTICE of that SCIENCE:

ITS APPLICATION TO

NATURAL PHILOSOPHY, || MEDICINE, AND
NATURAL HISTORY, || ANIMAL ECONOMY:

WITH

Full Explanations of the QUALITIES and MODES of ACTION of
CHEMICAL REMEDIES:

AND THE

FUNDAMENTAL PRINCIPLES

OF THE

ARTS, TRADES, and MANUFACTURES,

DEPENDENT ON CHEMISTRY.

TRANSLATED FROM THE FRENCH.

WITH

NOTES, ADDITIONS, and PLATES.

THE SECOND EDITION.

TO WHICH IS ADDED, AS

AN APPENDIX,

A

TREATISE on the Various Kinds of PERMANENTLY
ELASTIC FLUIDS, or GASES.

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SAFFRE. *See* ZAFFRE.

SAFFRON. *(a)*.

SAFFRON *of* IRON. Chemiſts have given the name *ſaffron* to many preparations which have a yellow color, like that of ſaffron, and particularly to the earth or ruſt of iron which has that color.

As iron may be deprived of its phlogiſton by the combined action of air and of water, by that of air and fire, and, laſtly, by acids, different names have been given to ſaffrons of Mars, or ferruginous earths prepared by theſe ſeveral agents. The ruſt of iron made by humid air is called *mar-*

(a) SAFFRON. Both water and ſpirit extract the color and virtue of ſaffron. The former liquor improves the ſmell and heightens the color, whilſt the ſpirit ſeems rather to weaken both. By drying two ounces and a half of the beſt ſaffron in the heat of a water-bath, half an ounce of liquor was obtained, which had an exceeding ſtrong ſmell, but had not the appearance of oil. This is the active part of the ſaffron, which diſorders the head and ſenſes. Six drams of extract were obtained from an ounce of dried ſaffron by means of water, and five drams and one ſcruple were obtained from another ounce by means of ſpirit. Rectified ſpirit acquired no ſmell or taſte by diſtillation from dried ſaffron; but water being thus diſtilled acquired a ſtrong ſmell. *Neuman.*

tial saffron prepared with dew, or *aperitive saffron of Mars.* Iron, dephlogisticated by vitriolic acid or sulphur, is also called *aperitive saffron of Mars.* Lastly, that which is reduced into a calx by the action of fire, is called *astringent saffron of Mars. See, for the medicinal virtues of these preparations of iron, the articles* ETHIOPS MARTIAL *and* IRON.

As the saffrons of iron acquire different shades of red and orange colors, which they preserve when melted with very fusible vitrified matters, they are employed for painting on enamel, on pottery, porcelain, and for giving color to glass, or imitations of precious stones.

SAFFRON *of* METALS. Saffron of metals is the metallic earth of antimony, half deprived of its sulphur and phlogiston by detonation of crude antimony with nitre, and afterwards well washed; or it is liver of antimony deprived of all saline matter by a sufficient washing. This preparation is a violent and uncertain emetic, not used by prudent physicians. *See* LIVER *of* ANTIMONY, *and* TARTAR (EMETIC).

SALMIAC. This word is an abridgement used by some for sal ammoniac. *See* AMMONIAC (SAL).

SALT. The word salt, which is synonimous with saline matter or saline substances, when taken in its most general sense, is of all chemical terms that which is applicable to the greatest number of individuals. In fact, the number of different bodies, which have what chemists call a saline character, or which possess the principal saline properties, is so great that they are very far from being all known, as we shall afterwards see.

The essential properties of all matter which ought to be considered as saline, are, to affect the sense of taste, to be soluble in water, and to have all the principal qualities, as gravity and fixity, in an intermediate degree betwixt those of water and of pure earth.

If we attend a little to the principal properties of the several bodies which are considered as salts or saline substances, we shall easily find that they do not all possess in the same degree the essential saline qualities that we have described. We shall see that some salts possess these qualities in the highest degree, while in others they are so weak and indistinct, that in many of them they can scarcely be discovered; and this diminution of the saline properties is so considerable in many compound bodies, that we may affirm that the limits which separate saline matters from others that

that are not saline, are unknown, indeterminate, and perhaps incapable of being determined.

We are certain, on the other side, that the saline substances whose properties are most distinct and strong, such, for instance, as the mineral acids, have great power over many other substances which have not a saline property; to which, by being combined together, they communicate more or less of their saline properties; or rather with which they form compounds, in which the saline properties are more or less sensible. Since experience shews that these saline compounds may be decomposed, so that the substance, which is not saline, shall be separated in its former state from the saline matter, which also shall recover the saline properties in the same force which it had before this union, we may from thence conclude;

First, that among the infinite multitude of bodies in which we may perceive saline properties, a very great number are composed of a substance essentially saline, and of one or more other substances not saline.

Secondly, that we ought to distinguish well substances which essentially possess saline properties from those which, not possessing any such properties themselves, are only capable of receiving more or less of them by uniting with substances of the former kind.

Thirdly, as the number of matters not saline which are capable of acquiring a saline character, or rather of forming compounds more or less saline by their union with substances essentially saline, is very great, the number of these last must be very small, in comparison of the number of compounds in which saline properties are perceptible.

To give some explanation of this extensive subject, we must begin by determining precisely what substances essentially saline are, and by assigning a character which can distinguish them from those, which, without containing any thing saline, may nevertheless make part of salts, by the union they are capable of contracting with the former. These characters are the following:

All those substances ought to be considered as essentially saline which have not only the characteristic properties of salts, as taste and perfect miscibility with water, in an eminent degree, but which also when disengaged can communicate these properties, at least in part, to the other substances which have them not, by combining with these latter, from which, when afterwards separated, they resume their former state and peculiar saline characters.

 All

All acids and alkalis, mineral, vegetable, or animal, fixed or volatile, fluid or concrete, muſt be conſidered as ſubſtances eſſentially ſaline. Each of theſe bodies has the properties we have mentioned. Some other ſubſtances have not the properties of acids or of alkalis very diſtinctly; but as they have the properties of ſalts in general, and are capable of acting as acids, and of communicating ſaline properties to the compounds into which they enter, they may therefore be conſidered as ſubſtances eſſentially ſaline. Such are *arſenic* and *ſedative ſalt*.

But if we reflect a little on the particular properties of each of the ſubſtances which ſeem to be eſſentially ſaline, we ſhall obſerve that they do not all poſſeſs theſe properties in the ſame degree. How great the difference is in this reſpect betwixt pure, concentrated vitriolic acid and the acid of tartar! They can ſcarcely be known to be ſubſtances of the ſame kind. The taſte ſimply acidulous of cream of tartar, its ſtate of conſtant cryſtallization and dryneſs, its little ſolubility in water, laſtly, the weakneſs of the adheſion which it contracts with all the ſubſtances with which it can unite, cannot be compared with the ſtrong and corroſive taſte of vitriolic acid, with the activity of its ſeizing moiſture, with the ſurprizing heat occaſioned by its mixture with water, laſtly, with the extreme force that keeps this body united to all the bodies with which it is capable of combining. The ſlighteſt view of the other ſubſtances eſſentially ſaline is ſufficient to ſhew that they differ much from each other, particularly in their degree of ſtrength; in a word, that they do not poſſeſs the ſaline properties in the ſame degree.

Theſe are the conſiderations which have undoubtedly determined the greateſt chemiſts, particularly Stahl, to believe that the number of ſubſtances truly and eſſentially ſaline is very ſmall, and even that only one ſaline principle exiſts, which by the intimate union it is capable of contracting with ſeveral other ſubſtances, conſtitutes a certain number of matters which poſſeſs the ſaline properties in a degree ſufficiently ſtrong to preſerve theſe properties more or leſs in their ſeveral combinations with other matters that are not ſaline, and to recover them entirely when ſeparated from theſe combinations; ſo that as they do not themſelves undergo any decompoſition, and as they always appear again with the ſame properties after having been combined and ſeparated, they ſeem to be ſimple matters, eſſentially ſaline, although they really are compounds of ſeveral bodies,

dies, not saline, united intimately with one only saline principle, which is universal and always the same.

According to this notion, which is grand and perfectly analogous to the plan which nature seems constantly to pursue in the different orders of compounds, the question is to discover which is the most simple of all saline substances, and is the principle of all others. The best, and perhaps the only, method of determining in a question of this nature, is to compare together the several saline substances, and to consider that as the most simple of all, which possesses the saline properties in the most eminent degree, and which also appears upon all occasions to be least susceptible of decomposition or alteration; for all chemistry shews us, that these are the characters of the most simple bodies, which are capable of becoming principles of more compound bodies: but when we examine all the saline matters under this point of view, we shall soon easily discover that we must begin by excluding all the saline matters called *neutral salts*; for any of these salts may be decomposed by ordinary chemical operations; and these decompositions shew that many of them are composed of two simpler saline substances, one of which is called *acid*, and the other *alkali*; also, acids and alkalis are not in general so easily altered as neutral salts. In the classes therefore of these two saline substances, we must search for that which is the most pure and simple of all.

If we continue this inquiry upon the same principles, and compare together the saline properties of the purest and strongest acids and alkalis, we shall easily be convinced that the saline properties are stronger and more distinct in acids than in alkalis, since the former are more active, more dissolving, more adhering to the bodies dissolved, more deliquescent, &c. and also, that in the several operations of chemistry, alkalis fixed and volatile appear to be more susceptible of alteration and decomposition than acids. Amongst acids, therefore, we must search for the strongest and simplest saline matter.

Lastly, when we examine in the same manner, and compare together all the substances which have the principal properties of acids, and which are called acids, we shall clearly perceive that those which are truly vegetable and animal, that is, in the combination of which oil enters, are infinitely more weak and susceptible of alteration than acids deprived of all oil, which we call mineral acids; amongst which, the vitriolic will be easily discovered to be

the ſtrongeſt and moſt unalterable, and conſequently of all bodies which have ſaline properties, the pureſt, ſimpleſt, and the moſt ſenſibly and eſſentially a ſalt.

Such conſiderations have undoubtedly induced the moſt profound chemiſts, and eſpecially the illuſtrious Stahl, to conſider this acid as the pureſt and ſimpleſt of all ſaline matters; and indeed all who are capable of reflecting on the greateſt and moſt important phenomena of chemiſtry, will conſider this propoſition as a demonſtrated truth. But Stahl carries this notion ſtill farther. From his writings, and the whole of his doctrine, we may infer, firſt, " That " he conſiders the vitriolic acid as the only ſubſtance eſſen- " tially ſaline; as the only ſaline principle, which, by " uniting more or leſs intimately with other ſubſtances that " are not ſaline, is capable of forming an innumerable " multitude of the other ſaline matters which nature and art " ſhew to us; and, ſecondly, that this ſaline principle is a " ſecondary principle, compoſed only of the intimate union " of two primary principles, *water* and *earth*."

Every true chemiſt will eaſily diſcover that this grand idea is capable of comprehending by its generality, and of connecting together, all the phenomena exhibited by ſaline ſubſtances. But we muſt at the ſame time acknowledge, that when we examine the proofs upon which it is founded, although it has a great appearance of truth by its conſiſtency with the principles of chemiſtry, and with many phenomena, yet it is not ſupported by a ſufficient number of facts and experiments to aſcertain its truth.

We might here examine what degree of probability ought to be granted to this theory of ſalts, but this could not be properly accompliſhed without entering into long details, and penetrating into the depths of chemiſtry; in a word, without making a full and compleat treatiſe, which cannot be admitted in a work of this nature. We are therefore obliged to relate only what is moſt eſſential to be known concerning this grand hypotheſis. We may perceive at once, that the former of theſe propoſitions, upon which is founded the theory which we mentioned, cannot be demonſtrated, unleſs it be previouſly proved that every ſaline matter, excepting pure vitriolic acid, is nothing but this ſame acid differently modified, the primary properties of which are more or leſs altered or diſguiſed by the union contracted with other ſubſtances. But we confeſs, that chemiſts are not capable of proving deciſively this opinion;

which,

which, however, will appear very probable from the following reflections.

First, of all saline matters known, none is so strong, so unalterable, so eminently possessed of saline properties, as *vitriolic acid.*

Secondly, amongst the other saline substances, those which appear most active, and most simple, as *nitrous* and *marine acids*, are at the same time those, whose properties most resemble the properties of vitriolic acid.

Thirdly, we may give to vitriolic acid many of the characteristic properties of nitrous acid, by combining it in a certain manner with the inflammable principle, as we see in the volatile sulphureous acid. *See* ACID (VOLATILE SULPHUREOUS), *and* ACID (NITROUS): and even, according to an experiment of Mr. Piech, related in a Memoir concerning the origin of nitre, which gained the prize of the Academy of Berlin, vitriolic acid, mixed with vegetable and animal matters susceptible of fermentation, is really transformed into a nitrous acid by the putrefaction of these matters.

Fourthly, the marine acid, although its principles are less known than those of the nitrous acid, may be approximated to the character of vitriolic and nitrous acids by certain methods. This acid, after it has been treated with tin and other metallic matters, is capable of forming ether with spirit of wine, as vitriolic acid does, which it cannot do in its natural state; and when iron is dissolved in it, it seems to be approximated to the nature of nitrous acid. Reciprocally, the approximation of vitriolic acid to the character of marine acid seems not impossible. Having once distilled very pure vitriolic acid upon a considerable quantity of white arsenic, I was struck with a strong smell like that of marine acid, which was not either that of arsenic or of vitriolic acid; for this has no smell, when it is pure.

Fifthly, oily vegetable acids become so much stronger, and more similar to vitriolic acid, as they are more perfectly deprived of their oily principle, by combining them with alkalis, earths, or metals, and afterwards by separating them from these substances by distillation, and especially by frequently repeating these operations. They might perhaps be reduced to a pure vitriolic acid, by continuing sufficiently this method: and reciprocally, vitriolic and nitrous acids weakened by water, and treated with much oily matters, or still better with spirit of wine, acquire the

characters of vegetable acids. We may see a remarkable instance of this in Mr. Pott's *Dissertatio de Acido Nitri Vinoso.*

Sixthly, the properties of fixed alkalis seem to be very different from those of acids in general, and consequently of vitriolic acid. Yet if we consider that a large quantity of earth enters their composition; that much of it may be separated by repeated solutions and calcinations; and also that by depriving these saline substances of their earthy principle, they become less fixed, more deliquescent, and, in a word, more similar to vitriolic acid in this respect; we shall not think it improbable, that fixed alkalis owe their saline properties to a saline principle of the nature of vitriolic acid, but much disguised by the quantity of earth, and probably of inflammable principle, to which it is united in these combinations. The properties of volatile alkalis, and the transformation of fixed alkali or of its materials into volatile alkali in putrefaction and in several distillations, seem to shew sufficiently that they are matters essentially saline, as fixed alkalis are, and that their volatility which distinguishes them proceeds from their containing a less quantity of earth, but more attenuated, and a portion of very subtle and volatile oil, which enters their composition.

Besides these principal facts, there are many others, too numerous to be even slightly mentioned here: they may be found scattered in the works of chemists, particularly of Stahl. But persons who would collect and compare all the experiments relating to this subject, ought to know, that many of them are not sufficiently ascertained, and that perhaps a greater number of them have not been sufficiently prosecuted, and are, properly speaking, only begun. We must even acknowledge, that many of those experiments which we have mentioned have not been sufficiently prosecuted. *See all the articles of Acids and Alkalis.*

The second fundamental proposition of the theory of salts, namely, "that the vitriolic acid is compounded of only the "aqueous and earthy principles," is, like the first, supported by many facts which give it a degree of probability, but which do not amount to a compleat demonstration. This proposition may be supported by the following considerations.

First, experience constantly shews, that the properties of compound bodies are always the result of those of the component parts of these bodies, or rather they are the properties of these component bodies modified by one another.

Thus,

Thus, if a body be compoſed of two principles, one of which is fixed and the other volatile, it will have a leſs degree of fixity than the former, and a leſs volatility than the latter. If it be compoſed of two principles, one of which is ſpecifically heavier than the other, its ſpecific gravity will be greater than that of one of them, and leſs than that of the other. The ſame obſervation is applicable to all the other eſſential properties, excepting thoſe which deſtroy each other, as, for inſtance, the tendency to combination, or the diſſolving power; for theſe latter properties are weakened ſo much more in the compounds, as their principles are more ſtrongly united, and in more juſt proportion.

We obſerve nevertheleſs, that the properties of compound bodies are not always exactly intermediate betwixt the properties of the component bodies; for, to produce this mean, the quantities of each of the component parts muſt be equal, which is the caſe in few or no compounds.

Beſides, ſome particular circumſtances in the manner in which the principles unite with one another, contribute more or leſs to alter the reſult of the combined properties; for inſtance, experience ſhews, that when ſeveral bodies, particularly metals, are united together, the ſpecific gravities of which are well known, the allay formed by ſuch union has not the preciſe ſpecific gravity which ought to reſult from the proportion of the allayed ſubſtances; but that in ſome allays it is greater, and in others leſs. But we are certain, on the other ſide, that theſe differences are too inconſiderable to prevent our diſtinguiſhing the properties of the principles in the compounds which they form, eſpecially when they have very different properties.

Theſe things being premiſed, when we examine well the properties of vitriolic acid, we ſhall eaſily find that they partake of the properties of the aqueous and of the earthy principles.

Firſt, when this acid is as pure as we can have it, it is like the pureſt water and the pureſt vitrifiable earths, free from color or ſmell, and perfectly tranſparent.

Secondly, although we cannot deprive the vitriolic acid of all the water ſuperabundant to its ſaline eſſence, and therefore its preciſe ſpecific gravity has not been determined, we know that when it is well concentrated, it is more than twice as heavy as pure water, and much leſs heavy than any earthy ſubſtance.

Thirdly,

Thirdly, this acid is much less fixed than any pure earth, since, however well it may be concentrated, it may always be entirely distilled; for which purpose, a much stronger degree of heat is requisite than for the distillation of pure water.

Fourthly, we do not know the degree of solidity of vitriolic acid, or the *adhesion of aggregation* which its integrant parts have one to another, because for this purpose the vitriolic acid ought to be deprived of all superabundant water; but if we judge of it by the solid consistence of this acid when highly concentrated, as we see from the vitriolic acid called *glacial*, the integrant parts of this acid seem susceptible of a much stronger adhesion than those of pure water, but much less than those of earth, as we see from the instance of hard stones.

Fifthly, the union which this acid contracts with water and with earths, shews that these substances enter into its composition: for we know that in general compounds are disposed to unite superabundantly with the principles which compose them. All these properties of vitriolic acid, which so sensibly partake, and much more than any other acid, of the properties of earth and of water, are sufficient to induce us to believe that it is composed of these two principles; but it has one very eminent property, which is common with it to neither water nor pure earth, which is, its violent and corrosive taste. This property is sufficient to raise doubts, if we could not explain it from principles which seem certain and general, relating to the combination of bodies. We shall here summarily recapitulate them, although we have spoken of them in several articles of this work, particularly at the words AFFINITY, AGGREGATION, SOLUTION, COMPOSITION, GRAVITY, SATURATION.

We observe then concerning the property now in question, that is, of taste in general, that it can only be considered as an irritation made upon the organs of taste by sapid bodies: and if we reflect attentively upon it, we shall be convinced that no substance that is not impressed by some impulse, can irritate or agitate our sensible organs, but by a peculiar force of its integrant parts, or by their tendency to combination, that is, by their dissolving power. According to this notion, the taste of bodies, or the impression made upon our sensible organs by their tendency to combination, or by their dissolving power, are the same property; and we see accordingly, that every solvent

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has a taste which is so much more strong, as its dissolving power is greater; that those whose taste is so violent that it amounts to acrimony, corrosion, and causticity, when applied to any other of the sensible parts of our body besides the organs of taste, excite in them itching and pain.

This being premised, the question is, how earth, in which we perceive no taste nor dissolving power, and water, which has but a very weak dissolving power, and little or no taste, should form by their combination a substance, such as the vitriolic acid is, powerfully corrosive and solvent?

To conceive this, let us consider, first, that every part of matter has a power by which it combines, or tends to combine with other parts of matter. Secondly, that this force, the effects of which are perceptible, in chemical operations, only among the very small molecules, or the integrant and constituent parts of bodies, seems proportionable to the density or specific gravity of these parts. Thirdly, that this same force is limited in every integrant molecule of matter; that if we consider this force as not satisfied, and consequently as a simple tendency to combination, it is the greatest possible in an integrant molecule of matter perfectly insulated, or attached to nothing, and is the smallest possible, or none, when it is satisfied by its intimate combination with other parts capable of exhausting all its action; its tendency is then changed into adhesion.

Hence we may infer, that the integrant parts of the earthy principle have essentially, and, like all the other parts of matter, a force of tendency to union, or of cohesion in union, according to their condition; that as this earthy principle has a much more considerable density or specific gravity than all other simple bodies that we know, we may probably presume that its primary integrant molecules have a more considerable force of tendency to union, in the same proportion, than the integrant parts of other principles; that consequently when they cohere together, and form an aggregate, their aggregation must also be stronger and firmer than that of any other body. Accordingly we see that the purest earthy substances, whose parts are united and form masses, such as, for instance, the stones called vitrifiable, are the hardest bodies in nature. We are no less certain, that as the tendency of the parts of matter to unite is so much less evident as it is more exhausted and satisfied in the aggregation, the parts of the earthy principle being capable of exhausting mutually all their tendency to union, we may thence infer, that every sensible mass of pure earthy matter

matter muſt appear deprived of any diſſolving power, of taſte, in a word, of tendency to union, from the firmneſs of its aggregation. But we may alſo infer, that when theſe primary integrant parts of the earthy principle are not united together in aggregation, then, reſuming all the activity and tendency to union which are eſſential to them, they muſt be the ſtrongeſt and moſt powerful of all ſolvents.

Theſe being premiſed, if we ſuppoſe again, with Stahl and the beſt chemiſts, that in the combination of the ſaline principle or of vitriolic acid, the parts of the earthy principle are united, not with each other, as in the earthy aggregation, but with the primary parts of the aqueous principle, each to each, we may then eaſily conceive that the primary integrant parts of the water having eſſentially much leſs tendency to combination than thoſe of earth, the tendency of theſe latter to union will not be exhauſted, but ſatisfied only partly, by their combination with the former, and that conſequently a compound muſt reſult, the integrant parts of which will have a ſtrong diſſolving power, as vitriolic acid is.

We may ſee from hence how much miſtaken chemiſts are, who, conſidering earth only in its aggregation, or rather not attending to this ſtate, and not diſtinguiſhing it from that ſtate in which the parts of this ſame earth are ſo ſeparated from each other by the interpoſition of another body, that they cannot touch or cohere together, have conſidered the earthy principle as a ſubſtance without force or action, and have very improperly called that a *paſſive principle*, which of all others is the ſtrongeſt, moſt active, and moſt powerful.

However this general theory of ſalts may conform with the moſt important phenomena of chemiſtry, we muſt acknowledge that it can only be propoſed as a ſyſtematical opinion, till it be evidently demonſtrated by the deciſive means employed in chemical demonſtrations, namely, by decompoſition and recompoſition: thus, if we could reduce vitriolic acid to earth and water, and make that acid by combining together theſe two principles, this theory would ceaſe to be a ſyſtem, and would become a demonſtrated truth. But we muſt confeſs that this theory is leſs ſupported by experiment than by argument, from the many difficulties that are inevitable in ſuch inquiries. For on one ſide, we know that the ſimpler bodies are, the more difficult is their decompoſition; and on the other ſide, the

ſtronger

ſtronger the aggregation is, the greater is the difficulty of making it enter into a new combination. Thus, as vitriolic acid is very ſimple, ſince it is a compound of the firſt order, it ought ſtrongly to reſiſt decompoſition: and as the aggregation of pure earth is the firmeſt that we know, it cannot eaſily be made to enter as a principle into a new combination with water to form a ſaline matter. The following are the principal experiments which have been made relative to this ſubject.

Firſt, we ſeem to be certain, from many proofs, that all ſaline ſubſtances, comprehending thoſe that contain vitriolic acid, as vitriolated tartar, Glauber's ſalt, and other vitriolic ſalts which are ſufficiently fixed to ſupport a perfect drying, or rather calcination, being alternately diſſolved, dried, and calcined a number of times, are more and more diminiſhed in quantity, and that earth and water are ſeparated from them each operation. But alkaline ſalts appear to be ſtill more ſuſceptible than any other ſaline matter of this kind of decompoſition.

Secondly, when nitre is burnt in cloſe veſſels, ſo that we may retain not only all that remains fixed after this burning, but alſo what exhales in vapors, as in the experiment of the clyſſus of nitre, we have a proof which ſeems deciſive, that the mineral acid of this ſalt, which is not very far from the ſimplicity of vitriolic acid, is totally decompoſed and reduced into earth and water. For if we examine the fixed reſiduum in the retort, we find that it is only the alkali that was contained in the nitre, charged with a ſuperabundant earth, which is ſeparable from it by ſolution and filtration. And if the liquor in the receiver, formed by the vapors condenſed there, be examined, which ought to be nitrous acid, if this acid had not been deſtroyed, we find that, ſo far from being acid, it is only pure water, ſometimes even charged with a little fixed alkali, which had been raiſed by the force of the detonation. Thus nitrous acid is made to diſappear in this experiment, and in its place we find only earth and water. *See* ACID (NITROUS), CLYSSUS *of* NITRE, DETONATION *of* NITRE, *and* NITRE.

Thirdly, the phenomena of limeſtone, which by calcination and extinction in water acquires ſaline properties that it had not before, its attenuation by fire, and its combination with water; and alſo the experiment of Beccher, who aſſerts, that if a vitrifiable ſtone be alternately made red-hot and extinguiſhed in water a number of times, it may be

ſo

so attenuated, that it shall be like a saline gelatinous matter; these, I say, shew that saline matters are actually formed by the intimate combination of the very attenuated parts of earth with those of water. We find in the writings of Beccher and Stahl, and particularly in the *Specimen Beccherianum* of the latter author, many other observations and experiments tending to prove the same proposition; but we must confess that none of the experiments we have mentioned, excepting that of the decomposition of nitrous acid by burning, are absolutely decisive, principally because they have not been sufficiently repeated, or prosecuted, nor carefully enough examined in all their circumstances.

Such is the actual state of the best theory of saline substances hitherto given. However fine and probable it may seem, it requires to be further illustrated, and better proved, especially by experiments. They who love inquiries into the sublimest parts of chemistry cannot engage in a more interesting subject.

As substances essentially saline, and particularly those of their combinations which are called *salts*, are very numerous, we shall here merely enumerate them, that we may have them at one view. For the details we refer to the particular article of each of these saline matters. We shall see by this kind of view, that although many combinations are known, many also are not known, because they have never been made; and many others are known but imperfectly, because they have not been sufficiently examined.

Substances essentially saline are, acids, alkalis, and neutral salts with basis of alkali.

The simplest and strongest acids, called *mineral acids*, are, *vitriolic acid*, called also *universal acid*, or *saline principle*.

Nitrous acid, commonly called *spirit of nitre* or *aqua-fortis*

Marine acid, called also *spirit of salt*, and *acid of common salt*. *See all these articles.*

The acids less simple and less strong than the mineral acids are those which have entered into the combinations of vegetables and animals, and which are united to a certain quantity of oil more or less attenuated. These are crystallized essential acid salts, such as *tartar*, called *cream* or *crystals of tartar*, when it is purified. *See* TARTAR.

The *acid of vinegar*, which proceeds from an acid fermentation, and is itself not only oily, but also spirituous. *See* VINEGAR.

The

The *unfermented acids of sharp fruits and plants*, as the juice of *goosberries*, *citrons*, *sorrel*, &c. These acids have not been examined.

The acids and acid spirit obtained in the distillation of vegetables, of their extracts, essential salts, oils, balsams, and resins. As all these acids are united to an empyreumatic oil, they may be called *empyreumatic acids*. They have not been examined.

The *acids obtained from animal substances* are:

The acid obtained in the distillation of *ants*, *flies*, and other *insects*; and the acid obtained in the distillation of *butter* or of *fat*. These acids are empyreumatic; they are very volatile, pungent, and penetrating. They have not been examined. *See* BUTTER *and* FAT.

Phosphoric acid, the origin and nature of which are not so well known that we can determine to what kingdom it belongs. *See* PHOSPHORUS *of* KUNCKEL, *and* SALT (FUSIBLE) *of* URINE.

Alkalis or *saline alkaline substances* are,

The fixed alkali of common salt, called also *mineral* or *fossil alkali*, *marine alkali*, *crystals and salt of soda*, because it is obtained by lixiviation and crystallization from the ashes called *soda*.

Vegetable, or *common fixed alkali*. It is often called salt of tartar, or alkali of tartar, in the works of chemists, because the ashes of tartar furnish the largest quantity of it. Both these fixed alkalis are called *caustic fixed alkali*, when they have been altered by quicklime, or by metallic calxes. *See* ALKALI (FIXED).

Volatile alkali. That is called *fluor volatile alkali* which has been altered by quicklime, or by metallic calxes, so that it afterwards cannot be obtained in a solid or concrete form. *See* ALKALI (VOLATILE).

NEUTRAL SALTS.

Formerly those only were called neutral salts which were composed of acids and alkalis united together to the point of saturation, so that they had no acid or alkaline property, and thence they were called neutral. But now this name is commonly extended to combinations of acids with all substances with which they can so unite, that they lose entirely, or mostly, their acid qualities, as, for instance, when they are united with earthy or metallic substances. We shall enumerate these neutral salts, observing the order of the acids already enumerated.

NITROUS SALTS.

Nitrous acid, combined with all the substances of which we have just mentioned the combinations with vitriolic acid, forms salts to which we may give the general names of *nitre* or *nitrous salt*, specifying each salt by the name of the substance united with the acid.

Nitrous acid with fixed vegetable alkali forms *ordinary nitre*, or *saltpetre*.

With marine alkali it forms *cubic* or *quadrangular nitre*.

With volatile alkali, *nitrous ammoniacal salt*, or *ammoniacal nitre*.

With calcareous earths, *nitre with basis of calcareous earth*.

With argillaceous earths, *nitre with basis of argillaceous earth*, a kind of *nitrous alum* little known.

With metallic substances, *metallic nitres*.

With gold, *nitre of gold*, unknown.

With silver, *nitre of silver*, *lunar nitre*, *lunar crystals*, or *crystals of silver*.

With copper, *nitre of copper*, or *cupreous nitre*.

With iron, *nitre of iron*, or *martial nitre*.

With tin, *nitre of tin*, unknown.

With lead, *nitre of lead*, or *crystals of lead*.

With mercury, *nitre of mercury*, *mercurial nitre*, *crystals of mercury*.

With regulus of antimony, *nitre of antimony*, unknown.

With bismuth, *nitre of bismuth*, *crystals of bismuth*.

With zinc, its calx and flowers, *nitre of zinc*, unknown.

With regulus of cobalt, *nitre of cobalt*, not much known. Mr. Beaumé has begun to examine it.

With arsenic and its regulus, *nitre of arsenic*, or *arsenical nitre*, very little known. *See* NITRES (METALLIC), *or with* METALLIC BASES. *See also the articles* ACID (NITROUS), *the articles of all the substances we have mentioned, and those of the nitrous salts which have particular names.*

MARINE SALTS, *or simply*, SALTS.

Marine acid forms with all these substances salts which may be called by the general name of *marine salts*, or simply *salts*, and specified by the names of their particular bases. Thus,

With marine alkali, it forms *common salt*, *kitchen salt*, *sea-salt*, when extracted from the sea, and *sal gem* when dug from the earth.

VITRIOLIC SALTS.

Vitriolic acid combined with marine alkali form[illegible] known by the name of *Glauber's salt*, or *sal mirabile*

With fixed vegetable alkali it forms a salt called *[illegible] tartar*, *[illegible] de duobus*, and *arcanum duplicatum*. [illegible]

With volatile alkali, it forms an ammoniacal sal[illegible] *vitriolic ammoniacal salt*, and *secret sal ammoniac of* [illegible] See AMMONIAC (SALT).

With calcareous earths, it forms *vitriolic salts of calcareous earth*, known by the general name [illegible] See that word.

With argillaceous earths, it forms a vitriolic s[illegible] *of argillaceous earth*, called *alum*. See ALUM.

With metallic substances, it forms different [illegible]

[illegible]

With gold, a salt little or not known, [illegible]

[illegible]

With silver, a salt but little known, [illegible]

With copper, a salt known by the name [illegible]

[illegible]

[illegible]

NITROUS SALTS.

... combined with all the substances of which ... the combinations with vitriolic acid, ... we may give the general names of nitre ... each salt by the name of the sub...

... vegetable alkali forms ordinary ...

... cubic or quadrangular nitre.

... ammoniacal salt, or ammoniacal ...

... basis of calcareous earth.

... basis of argillaceous ...

... lunar crystals, or ...

... nitre.

... lead.

... al nitre, crystals of ...

... much.

... nations ... acid ... with ... ith ... which ... e pro... which ... distill... a ex... ony. ... oper... nces ... strate ... , comp... eral a ... any of ... culiar ... have been ... y others, ... cion. See ... ubstances.

SALTS.

combination... getable acid...

... of the a... nalogous

With fixed vegetable alkali, *common salt with basis of vegetable alkali*, called *febrifugal salt of Sylvius* improperly, because it is no more febrifugal than any other; and still more improperly called *regenerated sea-salt*, because it differs essentially from sea-salt by the nature of its basis.

With volatile alkali, it forms *sal ammoniac*, formerly *armoniac*, and by some chemists called *salmiac*.

With calcareous earths, a *salt with basis of calcareous earth*. As this salt is obtained in the decomposition of sal ammoniac by means of quicklime, or other calcareous earths, chemists have improperly called the salt made in this manner *fixed ammoniac*, when it is dry; and *oil of lime*, when it is liquid.

With argillaceous earths, it forms a *salt with basis of argillaceous earth*, very little or not known.

With metallic substances, it forms *salts with metallic bases*, specified by the name of each base. Thus,

With gold, it forms a *salt of gold*, unknown.

With silver, it forms a *salt of silver*, known by the name of *luna cornea*.

With copper, it forms a *salt of copper*, not much examined.

With iron, a *salt of iron*, or *martial salt*, not much examined.

With tin, a *salt of tin*. This combination, like those of the marine acid with metallic matters, may be made by dissolving immediately the metal in the acid: but it may be still better made by decomposing, with the assistance of heat, and by means of the metal intended to be united with the marine acid, a combination already made of this acid with some other metallic substance; which is always possible when the affinity of the metal to be combined is greater than that of the metal already combined. Thus we may form easily a crystallizable salt of tin, by dissolving this metal directly in marine acid in the usual manner: this salt is but little known. The same combination is made by decomposing corrosive sublimate by means of tin, and by distillation. Thus we may obtain a combination of tin with marine acid, one part of which passes with excess of acid in form of a very smoking liquor, called *smoking spirit of Libavius*; and the other part which does not smoke, and which contains a larger proportion of tin, is sublimed in a solid state, and is called *butter of tin*.

With lead, *salt of lead*, known also by the name *plumbum corneum*.

With

With mercury, *salt of mercury*. It has different names according to the manner of making it, and according to the proportions of marine acid and mercury. It is called *white precipitate*, when it is separated from the nitrous acid by means of marine acid; *mercury corrosive sublimate*, or simply, *corrosive sublimate*, when it is actually sublimed, and with such proportions of mercury and acid, that a very corrosive salt results from them; *sweet mercury*, *sweet sublimate*, and *aquila alba*, when sublimed with an additional quantity of mercury by which its corrosive quality is blunted.

With regulus of antimony, it forms an *antimonial salt* by distillation. It is called *butter of antimony*.

With bismuth, it forms a *salt of bismuth*, not much examined.

With zinc, and its calx and flowers, a *salt of zinc*, little known.

With regulus of cobalt, a *salt of cobalt*, also little known.

With arsenic and its regulus, a *salt of arsenic*, or *butter of arsenic*, little known.

We may observe concerning all these combinations of marine acid with metallic matters, that, as this acid is very volatile, and as it is capable of adhering strongly with these substances, it does accordingly carry along with it more or less of them in sublimations and distillations; which is the reason that these salts are variable, as to the proportions of acid and metal which unite together, or which remain united, either directly by solution, or by distillation and sublimation, as we see from the phenomena exhibited by corneous metals, as tin and regulus of antimony. Although chemists, and still more, alchemists, have operated much on certain combinations of metallic substances with marine acid, much yet remains to be done to illustrate this subject.

We may here observe, that aqua regia, composed of nitrous and marine acids, which is in general a great solvent of metallic matters, must form with many of them mixed salts, some of which are perhaps of peculiar natures: but these combinations do not seem to have been examined hitherto as salts, no more than many others, as we may easily see from the present enumeration. *See the articles* ACID (MARINE), *and of the several substances with which we have mentioned its combinations.*

TARTAREOUS SALTS.

We shall give this name to the combinations of the acid of tartar, or of other concrete vegetable acids analogous to

it, with the several substances capable of uniting with these acids. But very few of these salts are known, which are in general called *soluble tartars*, because they are all more soluble in water than the acid of tartar itself.

The combination of cream of tartar with fixed vegetable alkali forms a neutral crystallizable salt, called *soluble tartar*, *tartarised tartar*, and *vegetable salt*. *See this latter word.*

With marine alkali, it forms the salt known by the name of *salt of Saignette*, *sal polychrest*, *salt of Rochelle*.

With volatile alkali, a *soluble ammoniac tartar*, unknown.

With calcareous earths, *soluble tartars with basis of calcareous earth*, very little known, but which appear similar to the *soluble tartars with basis of fixed alkali*.

With argillaceous earths, *soluble tartars with basis of argillaceous earth*, unknown.

With metals, *soluble tartars with metallic bases*, *soluble tartars of gold*, *of silver*, &c. which are all unknown, excepting the soluble tartars with basis of *iron* and of *glass of antimony*. The former is deliquescent, and called, when liquid, *tartarised tincture of iron*, or *of Mars*; and when evaporated, *martial extract*. It ought to be called *soluble martial tartar*. *See* TARTAR (SOLUBLE), *and the other names here mentioned.* The second soluble tartar with metallic basis is called *emetic* or *stibiated tartar*. *See* TARTAR (EMETIC).

ACETOUS SALTS.

We shall give this name to all salts containing the acid of vinegar.

With fixed vegetable alkali, it forms a *deliquescent salt*, called improperly *terra foliata tartari*, and *regenerated tartar*.

With marine alkali, it forms a crystallizable salt not much known, to which no name has been given. It may be called *acetous salt with basis of marine alkali*.

With volatile alkali, an *acetous ammoniacal salt*, imperfectly known, and named *spirit of Mindererus*.

With calcareous earths, several *acetous salts with calcareous bases*, very similar one to another, and susceptible of crystallizing, and forming beautiful *silky vegetations*, some of which are superficially known, and named *salts of chalk*, *of crabs eyes*, *of coral*, &c.

With argillaceous earths, *an acetous argillaceous salt*, unknown.

With metallic substances, an *acetous salt with metallic basis*, *of gold*, *silver*, &c. which are all unknown, excepting the three following:

With

With copper, an *acetous salt of copper*, known in chemistry by the names, *crystals of Venus*, or *of Verdigrise*, and in commerce and arts by the name *distilled*, or *crystallized verdigrise*.

With lead, an *acetous salt of lead*, known by the name of *salt*, or *sugar of lead*.

With mercury, an *acetous mercurial salt*, lately so named, but little known.

VEGETABLE SALTS.

This general name may be given to all neutral salts composed of the *acid juices*, *concrete salts*, *natural* or *unfermented acids of vegetables*, with the several substances capable of uniting with these acids; but none of these salts are yet known.

VEGETABLE EMPYREUMATIC SALTS.

Neither do we know any thing of the salts which might be formed with the acids obtained by the distillation of vegetable matters, which furnish acid spirits or concrete acids, and which might be called *vegetable empyreumatic salts*.

ANIMAL EMPYREUMATIC SALTS.

By this name we may distinguish neutral salts composed with acids obtained from the distillation of animal matters, as the *acids of insects*, *of butter*, and *of fat*; but all these salts are perfectly unknown.

Although we have given the epithet *empyreumatic* to salts formed with vegetable and animal acids, obtained by distillation of these substances with a heat greater than that of boiling water, we do not mean to imply, that these salts, if they were well made and purified, would retain an empyreumatic character, or any part of the burnt oil which adheres to these acids after distillation. On the contrary, these acids may be deprived entirely or partly of this oil by passing into combinations of neutral salts, as happens to volatile alkalis when transformed into ammoniacal salts: but in this case we should be better able to examine the nature of these acids, and the epithet empyreumatic would only refer to the manner of obtaining them, and would serve to distinguish them from those vegetable or animal salts, the acids of which have been obtained without distillation in a naked fire.

PHOSPHORIC SALTS.

By this general name we mean all ſalts produced by combining the acid of *phoſphorus of urine* with alkaline, earthy, and metallic ſubſtances, a ſmall part of which ſalts is known even imperfectly.

With fixed vegetable alkali, this acid forms a *phoſphoric ſalt*, a kind of *fuſible ſalt of urine*.

With marine alkali, it forms another *phoſphoric ſalt*, or *fuſible ſalt of urine with baſis of marine alkali*. It is not known.

With volatile alkali, a *phoſphoric ammoniacal ſalt*, called alſo *fuſible ſalt of urine*, *native ſalt of urine*, *microcoſmic ſalt*.

With calcareous and argillaceous earths, *phoſphoric*, *calcareous*, *and argillaceous ſalts*, not known.

With metallic ſubſtances, *phoſphoric metallic ſalts of gold*, *ſilver*, *copper*, &c. very little known. *See the article* PHOSPHORUS.

Beſides the ſaline ſubſtances which have ſenſible acid properties, ſome ſubſtances, as ſedative ſalt and arſenic, without having theſe properties, do nevertheleſs act as acids in their combinations with all ſubſtances capable of uniting with true acids, of forming with theſe ſubſtances kinds of neutral ſalts, and even of communicating, like the acids properly ſo called, ſaline properties to thoſe ſubſtances which have them not. Theſe combinations are by general conſent claſſed amongſt neutral ſalts.

BORAX, *or* SALTS *of* BORAX.

The ſedative ſalt, combined with marine alkali, forms *ordinary borax*.

With fixed vegetable alkali, a kind of *borax*, not much known.

With volatile alkali, an *ammoniacal borax*, not much known.

With calcareous and argillaceous earths, *calcareous* and *argillaceous borax*, unknown.

With metals, *borax with metallic baſes of gold*, *ſilver*, &c. unknown.

ARSENICAL SALTS.

Arſenic forms, with fixed vegetable alkali, a neutral ſalt perfectly ſoluble in water, and cryſtallizable, called by Mr. Macquer,

Macquer, who first observed it, *neutral arsenical salt*, or simply *arsenical salt*. *See* ARSENIC, *and* SALT (NEUTRAL ARSENICAL).

With marine alkali, another arsenical salt, very like the former, but not much examined.

With volatile alkali, an *arsenical ammoniacal salt*, unknown.

With calcareous and argillaceous earths, a *calcareous* or *argillaceous arsenical salt*, unknown.

With metallic substances, arsenic is perhaps capable of forming *arsenical salts with metallic bases*, or combinations in which saline properties would be perceptible, if these combinations were made by decomposing nitrous salts with metallic bases by means of arsenic, or by precipitating metals dissolved in acids by means of a solution of neutral arsenical salt in water; but perhaps from thence nothing would be produced but combinations similar to the arsenical minerals. We are quite ignorant upon this subject.

Saline alkaline substances, besides the salts which they can form with acids, can also act upon earths and metals, with which they form saline compounds, and from which, when separated, they appear as before. Accordingly, these compounds may for this reason be ranked amongst salts, and general and particular denominations may be assigned to them, according to the principles which compose them, as, for example, *alkaline earthy salts*, *calcareous*, *argillaceous*, *vitreous*, *metallic*, as of *gold*, *silver*, &c. But hitherto chemists have not considered them in this view, and have even examined them but little.

Lastly, acids, alkalis, and even several neutral salts may, by combining with oily substances, form compounds which may be considered as true salts, if this name be given, as it ought to be, to every thing that is sapid and soluble in water; but these compounds form in some measure a distinct class, and are distinguished by the name of *soap*. *See* SOAP.

From this enumeration of saline compounds we may see how many of them are little known, or not even thought of. The numerous experiments yet to be made in this extensive part of chemistry are nevertheless very necessary, and are fundamental and elementary. To make them successfully, nothing is requisite but accuracy, patience, and knowledge of the first principles of chemistry. Every intelligent person is capable of making them. For this purpose the acids, alkalis, earths and metals employed must be very pure, the saline compounds resulting from their union

muſt be examined; their taſte, ſolubility in water, cryſtallization, deliqueſcence, and the methods of decompoſing them muſt be obſerved. Theſe conſiderations are certainly ſufficient to excite the zeal of perſons who would contribute to the progreſs of chemiſtry.

We now proceed to treat ſummarily of the principal ſalts known by the name of ſalts, in an alphabetical order.

ACID SALTS.

Some chemiſts, and particularly ancient chemiſts, have thus named the ſaline ſubſtances which we only call *acids*. *See* ACIDS. We may however continue this name, and apply it to ſome concrete ſaline ſubſtances, as *tartar*, ſalt of *ſorrel*, &c. and to ſeveral other eſſential ſalts, which ſeem to be intermediate betwixt the ſtate of pure acids and of neutral ſalts.

SALTS *with* BASES ALKALINE, EARTHY *and* METALLIC.

By theſe general denominations the ſeveral neutral ſalts are diſtinguiſhed according to the nature of the baſis, or ſubſtance with which the acid is combined. *See the above enumeration of ſalts. See alſo the article* NEUTRAL SALTS.

SALT ALEMBROTH.

This is a ſaline matter, compoſed of *corroſive ſublimate* and of *ſal ammoniac*, mixed in equal parts, or in other different proportions, which the ancient chemiſts, eſpecially the alchemiſts, have much employed as a powerful ſolvent of metals, and even of gold. We are certain that corroſive ſublimate and ſal ammoniac act powerfully one upon another, and combine together without being decompoſed, from which is formed a ſaline compound of a ſingular nature, capable of acting very effectually upon metallic ſubſtances. But the alchemiſts, who made ſo much uſe of this famous ſolvent, were far from underſtanding clearly the operations in which they employed it. As alchemiſts loved pompous names, they called this compound *ſalt of art*, *ſalt of wiſdom*, *ſalt of ſcience*.

ALKALINE

ALKALINE SALTS.

This name is frequently given to saline alkaline substances, as *fixed alkalis*, *vegetable* and *mineral*, *volatile alkali*. *See these words.*

SALT *of* AMBER, *or* VOLATILE SALT *of* AMBER.

This is a saline, oily, concrete matter, obtained by sublimation, or even by crystallization, from amber. It is a kind of essential salt, which forms shining needle-like crystals, has the smell of rectified oil of amber, and is soluble in spirit of wine. It is used only medicinally, as an antispasmodic, with the same effect as the spirit and rectified oil of amber. *See* BITUMENS *and* SALTS (ESSENTIAL).

AMMONIACAL SALTS.

By this name are distinguished all neutral salts composed of any acid saturated with volatile alkali. *See* AMMONIACAL SALTS; *and* SALTS (NEUTRAL).

ARSENICAL SALTS.

See SALT (NEUTRAL ARSENICAL).

COMMON SALT.

Common salt is a neutral perfect salt, composed of a peculiar acid and a peculiar alkali, which are called *marine acid*, and *marine* or *mineral alkali*.

This salt, which is produced by nature, is more abundantly and universally diffused than any other. Immense mines or quarries of it are found within the earth, and it is then called *sal gem* or *fossil salt*. The waters of all the sea, and many subterranean and mineral waters, contain it. From every vegetable or animal chemists can extract it.

The taste of common salt is agreeable and moderately strong. It is crystallizable, and is one of those the figure of whose crystals is most regular, most determinate, and least variable. The crystals of this salt are perfect, or nearly perfect cubes; for the hollow pyramids obtained in certain evaporations of salt waters are nothing but a heap of cubical crystals, arranged in this manner near each other, by means of evaporation.

Common salt is moderately soluble in water. Four parts of water are required to dissolve one part of salt; and hot or boiling water dissolves no more of it than cold water.

For

For which reaſon it is only obtainable from ſea-water, and other waters impregnated with it, by a continued evaporation. *See* CRYSTALLIZATION.

Although common ſalt be very cryſtallizable, and exactly neutral, it very readily becomes moiſt when expoſed to humid air. It muſt be preſerved in very dry places.

This ſalt is ſuſceptible of contracting a certain union with *common ſalt with calcareous baſis*; for which reaſon all the ſalt obtained either from ſea-water or ſalt fountains always contains a certain quantity of this ſalt with earthy baſis. Thus, if any common ſalt be diſſolved in very pure water, and fixed alkali be added to this ſolution, we ſoon ſee the white earth of the ſalt with earthy baſis which is precipitated. As therefore cryſtallization ſeems inſufficient for the purification of common ſalt from the ſalt with earthy baſis, when we would obtain a very pure common ſalt, as is neceſſary for ſome delicate operations, we muſt diſſolve it in water, filtrate it, and add to it a ſolution of cryſtals of ſoda, or marine alkali, till no more white cloud is formed by the addition; then filtrate again the liquor, and evaporate. By this method we ſhall obtain a common ſalt perfectly pure. *(b)*

Common ſalt, expoſed to the action of fire, crackles and decrepitates pretty ſtrongly, when heated to a certain degree, eſpecially if it be heated haſtily. Its cryſtals burſt into ſmall pieces during this decrepitation. This effect is produced by the water of the cryſtallization of the ſalt, which being confined by the parts of the ſalt, and at the ſame time reduced into vapors by the action of fire, burſts the parts of the ſalt, and is diſſipated. Many chemiſts conſider this decrepitation of common ſalt as a pro-

(b) Sea-water contains diſſolved in it not only ſea-ſalt, or a combination of marine acid with mineral alkali, but alſo other ſalts, eſpecially combinations of marine and vitriolic acids with the earth called magneſia, which is not calcareous. *See* MAGNESIA, *and the Note ſubjoined*. Some of theſe ſalts, with baſis of magneſia, are cryſtallized along with the ſea ſalt by the evaporation of the ſea-water, and part of them remains in the reſiduous liquor called the mother-water. Some portion of true calcareous earth, diſſolved by marine and vitriolic acids, is ſaid alſo to be contained in ſea-water; but the quantity of this is very ſmall in compariſon of the quantity of magneſia; to the precipitation of which, therefore, the cloud or turbid appearance given to ſea-water, or to a ſolution of common ſalt in water, is chiefly owing.

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perty peculiar to it, and by which it may be known; but vitriolated tartar, nitre of lead, and probably many other salts, are susceptible of a similar decrepitation.

If salt be exposed to a red-heat after this decrepitation, it fuses; and when afterwards cooled, it fixes in form of a white and almost opake mass; but excepting that it has lost the water of its crystallization, it is the same as before this exposure to fire.

Several chemists, having observed that when common salt is heated in a retort a little marine acid exhales from it while it contains any moisture, and that by adding more moisture more acid may be thus obtained, have believed that, by means of water, all its acid may be expelled from it. But they have been deceived; for this small quantity of acid obtained by repeated humectations and distillations proceeded only from the common salt with earthy basis, which, we have observed, is always mixed with common salt. From this earthy salt a proportion of acid may actually be obtained by this method: but M. Beaumé has found, that no acid can be thus expelled from common salt perfectly purified in the above-mentioned manner.

This salt is absolutely unalterable by fire, even when it has been heated strongly, together with inflammable matters. The unalterable property of common salt by fire proceeds from the small disposition which its acid has to combine with phlogiston. This truth has been demonstrated by the experiments of Mr. Duhamel and of Mr. Margraaf.

Although this salt be fixed in the fire to a certain degree, yet when it is exposed to a violent fire with free access of air, it exhales in vapors, and attaches itself in white flowers to bodies which it finds less hot than itself. We have examples of this effect in certain fusions of ores, where common salt is added; and in glass-house furnaces, where this salt, of which a certain quantity is contained in soda and potash, and which cannot enter into vitrification, attaches itself to the sides of the openings or holes.

We know no other acid but vitriolic and nitrous acids, and sedative salt, which can decompose common salt by disengaging its acid; for arsenic, which so easily and effectually decomposes nitre, cannot act upon this salt; a phenomenon, the cause of which deserves to be examined, and which is certainly connected with an important theory.

Common salt is of all saline substances the most necessary, and extensively useful. Besides the particular uses of its acid and alkali in many chemical operations and in arts;

besides its great utility in the fusion of glass, which it whitens and purifies, although it does not enter, and perhaps because it does enter into their combination, as Mr. d'Antic has shewn; and from the property it has of facilitating the fusion and precipitation of the metallic parts of minerals in essays, and of covering them perfectly; besides these, I say, its great use in aliments, the taste of which it improves by its agreeable piquancy, when mixed in proper quantity, is universally known. But this is not the only advantage; for it retards and prevents the putrefaction of almost all our aliments, without producing any such change upon them, even when preserved a long time by means of it, as to render them unfit for the purpose of nourishment. All other saline matters may indeed preserve from putrefaction, as common salt does, and some of them even more effectually: but we do not know any other, the taste of which renders it capable of being substituted to common salt for this purpose.

A very remarkable circumstance in the antiseptic property of common salt, and of some other salts, is, that this property varies surprisingly according to the proportions in which the salt is employed: for this salt, mixed with animal matters in a large proportion, preserves them from putrefaction, which it accelerates considerably when a small quantity only of it is employed. This singular fact is proved by the experiments of Messrs. Pringle and Macbride, and particularly by those of the accurate and intelligent author of *an Essay towards a History of Putrefaction*, Mr. Gardane, Physician of the Faculty of Paris, who, having convinced himself of this fact by his own experiments, mentioned it in a very good thesis, and has drawn from it a conclusion which seems to me very just, namely, that small quantities of common salt, such as those taken with aliments, facilitate digestion, which he considers as a beginning putrefaction. If this opinion be as true as it is probable and consistent with the principles of chemistry, and of the animal economy, then common salt is not only agreeable and useful, but also salutary, at least to all constitutions in which the digestion is too remote from putrefaction, as in those which are properly called *crudities:* for we cannot but agree, that different temperaments differ much in this respect. *See the articles* ACID (MARINE), ALKALI (MINERAL), CRYSTALLIZATION, WATER (SEA), WATER *of* SALT FOUNTAINS, SALTS, *and* SALTS (NEUTRAL).

CRY-

CRYSTALLIZABLE SALTS.

By this name we diſtinguiſh all ſaline matters ſuſceptible of cryſtallization. It is contrary to that of *fluor ſalts*, by which are diſtinguiſhed ſaline ſubſtances that cannot be obtained in a cryſtallized concrete form, ſuch as nitrous and marine acids, volatile alkali altered by quicklime, and ſome others. We have nevertheleſs reaſon to believe, that, rigorouſly ſpeaking, every ſaline ſubſtance is eſſentially ſuſceptible of cryſtallization, and that in this reſpect they only differ in the degree of facility with which they may be cryſtallized; for we are certain that many very deliqueſcent ſalts, the cryſtallization of which has not, that I know of, been ever obſerved, ſuch as *common ſalt with calcareous baſis*, may nevertheleſs aſſume ſolid regular forms by the cooling of their ſolutions when very much concentrated. Mr. Beaumé has obſerved the cryſtallization of this and ſeveral ſimilar ſalts. *See* CRYSTALLIZATION, DELIQUESCENCE, SALT, *and* SALTS (NEUTRAL).

SALTS *of* CENTAURY, *of* WORMWOOD, *of* SORREL, &c.

The name of *ſalt*, added to the proper name of ſome ſubſtance, is applied to very different matters. It is given, for example, to all the fixed alkalis obtained from the aſhes of vegetable matters. Salts of wormwood, centaury, &c. are ſaline matters obtained by lixiviating the aſhes of theſe plants: but theſe names are improper in ſeveral reſpects; for if we apply them to the fixed alkalis of plants, as they do not differ from each other, it is uſeleſs to diſtinguiſh them by the name of the plant from which they are obtained; and even when they are prepared in Tachenius's method, although they differ a little, yet their character of fixed alkali is ſo predominant, that no name ought to be given to them but what has a relation to that character. Accordingly, the names *ſalt of tartar*, *ſalt of ſoda*, which are frequently given to the alkalis of theſe ſubſtances, are for the ſame reaſon very improper. They ought to be called *alkali of tartar* and *alkali of ſoda*.

Certain concrete acids, as the eſſential ſalt of ſorrel, tartar &c. are alſo ſimply called *ſalt of ſorrel*, &c. This is alſo faulty, becauſe theſe names do not denote the nature of the ſaline matters, and may be the occaſion of confounding them with other ſalts of a very different nature. They ought

ought to be named *essential salts*, or rather *concrete acids of sorrel*, *of tartar*, &c.

The names *salts of coral*, *of pearls*, *of crabs eyes*, are not more accurate, unless we add the epithet *acetous*, as *acetous salt of coral*, &c. for these substances may be combined, and may form salts with any other acid, as well as with vinegar.

Let us now judge if the names, *salt of quinquina*, *of sena*, *of onions*, &c. given to the dry extracts of these matters made in the manner of the Count de la Garaye, are not entirely improper. *See the preceding enumeration of salts.*

SALT *of* COLCOTHAR.

This is a white saline matter, obtained by lixiviating colcothar. This matter is not much used, and has not been much examined. It is probably some *selenitic* or *aluminous* substance, which is mixed with the vitriol, and which was contained in the pyrites from which the vitriol was extracted.

SAL DE DUOBUS.

It is a neutral salt, formed by saturating vitriolic acid with the alkali of nitre. *See* TARTAR (VITRIOLATED).

DELIQUESCENT SALTS.

Thus are named all saline matters which may be obtained by crystallization or drying in a concrete form, but which, when exposed to air, imbibe its moisture, and lose their concrete crystallized form, deliquiating into a liquor by means of this moisture. *See* DELIQUESCENCE.

SALTS *of* ENGLAND, *of* EPSOM, *of* SEDLITZ.

Some saline substances have been denominated from the countries where they have been first discovered. Thus a very rectified concrete volatile alkali, obtained from silk, is called *salt of England*; and even some druggists give this name to the concrete volatile alkali obtained from sal ammoniac.

In a similar manner, the name of Epsom salt is given to a badly crystallized, bitter Glauber's salt, which easily becomes moist because it is mixed with common salt, and common salt with calcareous basis. It was first obtained from a salt well at Epsom, near London. This name has been since given to a similar

-'s salt obtained from salt marshes in France, ue and pure Glauber's salt obtained from the . salt-works of Lorraine and Franche-Compté, ,zation of which they disturb purposely to prevent resembling entirely the pure salt of Glauber. *See a to the Article* GLAUBER'S SALT.

Salt of Sedlitz is also a Glauber's salt under another name; and perhaps the same may be said of many other salts denominated from places.

ESSENTIAL SALTS.

This name is given to all concrete saline matters which preserve the smell, taste, and all other principal qualities of bodies from which they were obtained, which bodies are only vegetable and animal. The usual method of preparing them is by evaporating, to almost the consistence of a syrup, the liquors containing the essential salt, namely, the expressed and depurated juices and strong decoctions, and by keeping them in a cold place. From many of these liquors, saline matters or crystals are deposited upon the sides of the containing vessels after a considerable time, and after they have undergone a kind of fermentation. These crystals, which are always very red, may be purified by dissolving them in water, filtrating, evaporating, and crystallizing.

We may observe, that the salts thus obtained from animal and vegetable matters are sometimes nothing but vitriolated tartar, Glauber's salt, nitre, common salt, and other such neutral salts, which ought not to be considered as the essential salts of the substances from which they are extracted.

These mineral salts are extraneous to the vegetables and animals from which they are obtained. They are not parts of those substances, nor are combined with them; and when they are purified from the extractive matter with which they are at first only mixed and covered over, they have then nothing vegetable or animal. These salts are introduced into vegetables and animals along with aliments, are mixed in their liquors and circulate in their vessels, but receive no alteration, nor contract any true union with the proximate principles of animals and vegetables, because they are naturally incapable of such union.

The proof of this truth is, that they are always obtained from vegetables and animals in the same state in which they were introduced, and that their quantity in these substances is altogether inconstant and variable, without any real difference

difference being produced in the vegetables or animals by this variation of the quantity of these salts. Certain plants, as the *parictaria*, but still more the *corona solis*, have the property of imbibing so much nitre, that, when they grow in nitrous soils, they are almost filled with this salt. I have seen the dried pith of corona solis so full of crystallized nitre, that when shook over a paper, a considerable quantity of good deflagrating nitre might be collected. But we know also that this plant, when cultivated in a less nitrous soil, does not contain nearly the same quantity of nitre, although it be otherwise in good condition. These mineral salts therefore must not be considered as the essential salts of plants or animals; and only those salts are to be considered as such, in the combination of which we find oily parts, which cannot be separated from them, unless the salt be decomposed.

In the second place we shall observe, concerning salts truly called essential, that but very few of them are yet known, and most of these but very imperfectly. Of all these essential salts the best known is tartar, the properties of which may be seen under the article TARTAR. The druggists have a very white concrete salt, well crystallized, and soluble in water, which they call *salt of sorrel.* We may indeed obtain from the juice of sorrel, by the above-mentioned process, an essential acid concrete salt, but much more earthy and less acid than the salt above-mentioned. Besides, Mr. Beaumé, who has made some inquiries into this matter, affirms, that a true salt of sorrel could not be procured at the price of the salt which is commonly sold under that name, the quantity of salt obtainable from sorrel being very small. The salt above-mentioned is brought from Germany, is much more acid and more soluble in water than cream of tartar; it acts upon all substances soluble by acids; but the neutral salts thence formed have not been examined.

Flowers of benjamin, *volatile salt of amber*, and other saline matters of the same kind, seem to belong to this class of essential salts; but they are little known. Essential salts may be considered as a new subject of inquiry.

FIXED SALTS.

Many chemists give this name to the salts obtained from the ashes of plants, which not having been dissipated by fire, ought to be considered as fixed, in comparison of the other saline

saline matters of these plants, which evaporate during their deflagration.

As the saline substances remaining in the ashes of vegetables are entirely or chiefly alkaline, the name of *fixed salt* has become synonimous with that of *fixed alkali*. But other saline substances, as most neutral salts, which have not bases of volatile alkali, are nearly as fixed as fixed alkali.

The fixity of any saline matter is not perfect; since any of them by a long-continued violent fire may be altogether evaporated. A proof of this we find in glass-houses. A part of the fixed alkali, of the common salt, of Glauber's salt, of vitriolated tartar, and other equally fixed salts, contained in the ashes used in the composition of glass, are perpetually exhaling, during the fusion of glass, in a vapor which may be seen above the pots; and this vapor forms saline incrustations round the openings and other least hot places of the furnace. Accordingly, the quantity of salt of glass which covers the surface of the melted glass is continually diminishing. I have had occasion to take from a vitrifying furnace, at different times, eighty crucibles, containing all the same composition for crystal-glass, of which soda and pot-ash made parts. The crucibles first taken out were covered with a crust of salt of glass more than two lines thick; those taken out 18 or 20 hours afterwards had only a very thin stratum of glass-gall; and, lastly, the crucibles which remained 72 hours in the fire, had no salt, or only a very small quantity, upon the middle of the surface of glass.

Hence we ought to conclude, that the quality of fixity ascribed to some salts is only relative. We consider those as fixed which sustain a red heat during several hours, without any sensible diminution. Salts which by a red heat are reduced into vapors and sublimed, are called *semi-volatile*, as the ammoniacal salts, and corrosive sublimate; and lastly, salts which are dissipated without heat, or with very little heat, as the volatile acids and alkalis, are called *volatile salts*.

FLUOR SALTS.

This name is given to all saline substances which cannot by any method be rendered solid; such are nitrous and marine acids, volatile alkali altered by quicklime, and some others. This quality depends on their volatility, and on the affinity which they have with water superabundant

to their ſaline eſſence. In this latter point they reſemble deliqueſcent ſalts, and they may even be conſidered as ſalts perpetually and unſurmountably deliqueſcent. But they differ from ſalts that are only deliqueſcent, in this circumſtance, that theſe latter are much leſs volatile than the fluor ſalts, and can ſupport a heat ſufficient to deprive them of all their ſuperabundant water, and to reduce them to a concrete form. *See* DELIQUESCENCE *and* SALT.

FUSIBLE SALT *of* URINE.

This ſalt, called alſo *native* or *eſſential ſalt of urine*, *phoſphoric ſalt*, *microcoſmic ſalt*, is a neutral ſalt compoſed of an acid named *phoſphoric*, ſaturated with an alkali fixed or volatile; for both theſe kinds of alkalis ſeem to be contained in urine.

To obtain this ſalt, urine freſh or putrid is to be evaporated to the conſiſtence of a ſyrup, ſlowly or quickly. This urine, which is then very red, or brown, is to be put in a cold place. The fuſible ſalt cryſtallizes on the ſides of the veſſel. When the ſalt ceaſes to form itſelf on the veſſel, the liquor is to be decanted, and again evaporated, that ſtill more cryſtals may be obtained by the ſame method. Theſe cryſtals are to be collected, which are very dirty and brown. They may be purified by diſſolving in pure water, filtrating, evaporating, and cryſtallizing, according to the general method. Theſe operations ought to be repeated when the ſalt is required to be very white and pure. Thus they are diſengaged not only from the extractive part of the urine which diſcolors them, but alſo from a portion of common ſalt which may be mixed with them, particularly when the urine has been much evaporated.

This ſalt is very ſuſceptible of cryſtallization, and is one of thoſe which are more apt to cryſtallize by cold, than by evaporation.

If this ſalt be expoſed to the action of fire in cloſe veſſels, a very pungent volatile alkali is expelled from it, which Mr. Schloſſer has obſerved to be always fluor, like that which has been altered by quicklime. This chemiſt affirms even that if concrete volatile alkali be combined with the fuſible ſalt of urine, and ſeparated from this ſalt by diſtillation, it will be in a fluor ſtate.

The acid of this ſalt is fixed, and remains at the bottom of the veſſels, melted to a vitreous matter, if the heat has been

been sufficient for that purpose. This is the acid which produces the phosphorus of Kunckel, by its combination with the inflammable principle, and which gives the characteristic properties to the fusible salt of urine. *See the properties of this acid under the article* PHOSPHORUS *of* KUNCKEL.

If this fusible salt be mixed with the other fusible salt with basis of fixed alkali, as this latter salt cannot be decomposed merely by distillation, nor even by means of phlogiston, phosphorus is therefore chiefly produced from the former, or the ammoniacal fusible salt. *See* PHOSPHORUS *and* URINE. *(r)*

FOSSIL SALTS.

Thus are called all the salts obtained ready formed within the earth; but more particularly common salt, which is coagulated in large masses within the earth, more frequently called *sal gem*.

SAL GEM.

Sal gem is fossil common salt, or which is found within the earth in large masses: It has some transparency, by which it resembles crystal a little; and hence it has been called sal gem. The most considerable mines of this salt are in Poland. Very curious and interesting particulars

(r) Mr. Pott says, that the figure of fusible salts varies much according to the heat, evaporation, and different mode of crystallization; and that it assumes the shape of most others, as of saltpetre, vitriol, sal ammoniac, Glauber's salt, &c. but that it is generally in shining, octogonal, prismatic crystals. The taste of this salt is cool, not unlike that of borax, to which it is in other respects very similar. When put on the fire in a crucible, it froths, swells and melts. When melted upon a bit of charcoal by means of a blow-pipe, it forms a round drop.

The crystals of the second crystallization do also melt upon charcoal, when they are pure, but when cold they have a milky color. They do not, like the crystals of the first crystallization, form phosphorus with phlogiston. They effloresce in the air, and are hot to the taste, in both which instances they also differ from the first crystals. They have the properties of the Sal mirabile perlatum of M. Haupt.

These second crystals, which are a kind of Glauber's salt, are formed from the residuum of the crystallization of the fusible salt diluted with much water.

concerning these mines may be seen in a Memoir of Mr. Guettard, in the Memoirs of the Academy of Sciences.

SALT *of* GLASS.

This matter, called also *glass-gall*, is a kind of saline scum or mass, found in glass-house pots upon the surface of the melted glass. It consists of neutral salts, as common salt, vitriolated tartar, and others which are contained in the soda and potash employed in the composition of glass, and which not being themselves susceptible of vitrification, are separated from the glass during the fusion, and are collected together upon its surface, because they are specifically lighter. Hence we see, that as all the soda and potash employed for the composition of glass contain more or less of these extraneous neutral salts, the salt of glass must vary according to the saline substances employed. For the same reason no salt of glass is found where only pure and vitrifiable salts, as purified alkalis, nitre, borax, &c. are employed. *See* VITRIFICATION.

GLAUBER'S SALT.

The salt thus named, from the chemist who discovered it, is a neutral salt, composed of vitriolic acid saturated with marine alkali.

Glauber discovered this salt, while he was decomposing common salt, by means of vitriolic acid, to obtain the smoking marine acid by distillation. The residuum of this distillation he found to be a saline mass, not crystallized, which he dissolved in water, and obtained, by evaporation and cold, transparent crystals. Glauber, surprised with the appearance and properties of these crystals, gave them the name of *sal mirabile*, by which they are still known, but more generally by that of *Glauber*'s salt.

This salt, although composed of vitriolic acid and a fixed alkali, as vitriolated tartar is, yet it differs from this latter salt in many respects; which differences are to be attributed to the difference of the alkaline bases, one being the vegetable fixed alkali, and the other the marine fixed alkali. The taste of Glauber's salt is saltish, but disagreeable and bitter. It is one of the salts which form the finest crystals. When large quantities of this salt are crystallized, and with due attention, large, oblong, columnar crystals are formed, the surfaces of which are striated longitudinally, like those of nitre.

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The cryſtals of this ſalt are as tranſparent as ice, but when expoſed to a dry air they loſe their tranſparency by the evaporation of the water of their cryſtallization. Their ſurface, and afterwards the whole of the ſaline maſs, is reduced by the diſſipation of this water to a white ſaline powder. This change alſo happens to the cryſtals of marine alkali, to which probably this property of Glauber's ſalt muſt be attributed.

The quantity of water which enters into the cryſtallization of Glauber's ſalt is very conſiderable, and amounts to nearly one-half of its weight. To this large quantity of water is probably owing the ſize and tranſparency of the cryſtals: for it ſeems to be a general rule, that the more water is contained in any ſalt, the more large and tranſparent its cryſtals are. From this ſame abundance of water, Glauber's ſalt liquefies with a heat quickly applied, till all the water be evaporated; and then it becomes dry and ſolid, and requires greater degree of heat to fuſe it.

This ſalt, although very ſoluble, even in cold water, is one of thoſe which may be diſſolved in a leſs quantity of boiling than of cold water. Hot water diſſolves nearly an equal weight of it. From this property we may know, that the cryſtallization of Glauber's ſalt is beſt procured by the cooling of a ſufficiently evaporated ſolution. Accordingly, a ſure method of obtaining the fineſt cryſtals of ſalt of Glauber is, to evaporate the water, in which it is diſſolved, till we find by taking out and trying a ſmall quantity of the ſolution while evaporating, that cryſtals are pretty quickly formed by cooling. It is then to be poured into flat and ſhallow veſſels, and cooled ſlowly. The larger the quantity of liquor is operated upon at a time, the larger will the cryſtals be; ſo that they may be obtained ſeveral feet long, and proportionably thick. Theſe cryſtals are placed horizontally upon each other, and the cryſtallization ought therefore to be performed in wide veſſels. *See* CRYSTALLIZATION.

Glauber's ſalt cannot be directly decompoſed but by means of phlogiſton only: for the decompoſitions made of it by metallic ſolutions are by means of a double affinity: and the decompoſition which may be effected by the nitrous acid alone, upon Glauber's ſalt and vitriolated tartar, as Mr. Beaumé diſcovered, is alſo cauſed by phlogiſton. (*s*)

(*s*) Concerning the decompoſition of Glauber's ſalt, and of vitriolated tartar by nitrous acid, *ſee the article* TARTAR (VITRIOLATED), *and the note ſubjoined.*

Glauber's salt is used only in Medicine. In small doses, as from one to two gros, it is resolvent and aperitive, and as such is added to ptisans and apozems. It is also employed as an attenuant and corrective in the same dose in purgative potions; and is itself a good and mild purgative, as all the neutral salts are, the basis of which are fixed alkali: The dose of this salt as a purgative is from an ounce to an ounce and a half.

To prepare Glauber's salt, we need not combine the pure disengaged vitriolic acid with the alkali of soda, nor decompose common salt by vitriolic acid, as Glauber did, unless we desire to obtain at the same time the marine acid. Nature furnishes a large quantity of this salt already formed. A considerable quantity of it is contained in mineral waters, and perhaps all waters which contain common salt contain also some Glauber's salt. *(t)*. The salt wells of Lorraine, of Franche-Compte, of Epsom, contain much of it, and from these it may be easily obtained by crystallization. Further, from all vitriolic salts with earthy or metallic bases, as selenites, alums, vitriols, Glauber's salt may be obtained by decomposing them with soda. Lastly, by burning sulphur with common salt or soda, this salt may be formed. If it were much wanted, it might be easily and cheaply made by these processes. *See the articles* ACID (VITRIOLIC), ALKALI (MARINE), CRYSTALLIZATION, WATER *of the* SEA, *and of* SALT FOUNTAINS, SALT, *and* NEUTRAL SALTS.

(t) Glauber's salt, that is, a salt formed by vitriolic acid combined with mineral alkali, is contained in sea-water and in many mineral waters. But the *sal catharticus amarus* of the London Dispensatory, extracted from the bitter liquor remaining after crystallization of sea-salt in sea water, and the *salt of Epsom*, and of most purging waters, tho' very similar in appearance to the true Glauber's salt, with which it is frequently confounded, are found to be composed of vitriolic acid united with the earth called magnesia. *See* MAGNESIA. This salt consists of prismatic crystals like those of Glauber's salt; has a bitter taste; is soluble in less than an equal weight of water; when exposed to a moderate heat, it quickly liquefies, and loses the water of its crystallization, which amounts to more than half its weight; and is changed by this calcination into a white powder, almost totally soluble in water, by addition of which, together with evaporation, it may be restored to its former crystallized state.

SALT

SALT *of* LEAD.

Thus is commonly called the neutral ſalt compoſed of the acid of vinegar ſaturated with lead. As this ſalt has a ſweet and ſaccharine taſte, it is called *ſugar of lead.*

To make this acetous ſalt, ceruſs, which is lead half diſſolved, and corroded by vinegar, is to be entirely diſſolved in diſtilled vinegar by means of heat in a ſand-bath; the liquor, when perfectly ſaturated, is to be evaporated, and cryſtallized by cooling, and many ſmall needle-like cryſtals will be formed in it, which are to be well drained.

This ſalt is not much uſed in medicine. It is uſed only externally, becauſe the lead is pernicious. It is employed in ſome arts, and eſpecially in dyeing, to heighten the red color of madder. *See* CERUSS, LEAD, *and* VINEGAR.

LIXIVIAL SALTS.

This is a general name given to all ſaline ſubſtances obtained by lixiviation of aſhes, but particularly applied to fixed alkalis, becauſe the ſalts thus obtained from aſhes are altogether or moſtly alkaline. *See* ALKALI (FIXED).

NEUTRAL SALTS.

If this name be taken in its moſt extenſive ſenſe, it ought to be given to all the combinations of any acids with any alkaline, earthy, or metallic ſubſtances. Theſe are ſalts formed with baſis of fixed alkali, vegetable or marine; with baſis of volatile alkali, called ammoniacal ſalts; or with baſis of calcareous and argillaceous earths; and, laſtly, thoſe with baſes of metallic ſubſtances. *See the above enumeration of Salts.*

The name *neutral*, given to theſe ſalts, relates to the reciprocal ſaturation of their acids and their baſes. This ſaturation ought to be ſuch, that the properties of the two principles of the neutral ſalt ſhould be neither thoſe of a pure acid, nor of its pure baſis, but mixed or intermediate; and from hence theſe ſalts have alſo been called *intermediate ſalts*, or *ſales medii.*

The moſt important conſideration concerning theſe ſalts, is the juſt ſaturation of their two component principles. A neutral ſalt ought to be conſidered as perfect in its kind, when its acid and baſis are each of them in the moſt perfect relative ſaturation; that is, when the acid and the baſis are united together in as large quantity and as intimately as they can be, each according to its nature. But we muſt

remark upon this ſubject, that a neutral ſalt may be perfect in its kind, and exactly ſaturated in the ſenſe we have mentioned, although its principles be very far from being completely or abſolutely ſaturated, that is, although they have not exhauſted upon each other all their tendency to combine. In this reſpect the neutral ſalts differ much; and on this chiefly depend the eſſential differences evidently obſervable in the taſte, ſolubility, cryſtallization, deliqueſcence, facility of decompoſition, and action upon other ſubſtances, of theſe neutral ſalts.

From a circumſtantial examination only of the properties of neutral ſalts, we can acquire any knowledge concerning them; but we are far from having ſufficiently examined them: for beſides that many ſaline combinations are quite unknown, and have never been made, many things are yet undetermined even concerning thoſe ſalts which are beſt known. We need not therefore be ſurprized that we cannot yet eſtabliſh a good general theory concerning neutral ſalts. We ſhall here only mention ſome general principles which ſeem to reſult from what is already known, and which ſeem capable of leading us to further reſearches.

Firſt, the neutral ſalts, reſulting from the union of acids in general with fixed alkalis, are more abſolutely ſaturated than thoſe with baſis of volatile alkali, and theſe more than ſalts with baſis of earth, excepting ſelenites; and, laſtly, the ſalts with baſis of earth are more abſolutely ſaturated than ſalts with metallic baſes. In the firſt claſs of theſe ſalts, namely, thoſe with baſis of fixed alkali, we find moſt of the ſalts which have the leaſt taſte, ſolubility, deliqueſcence, action upon other bodies, or facility of decompoſition, and the greateſt tendency to cryſtallization. On the contrary, in the laſt claſs, namely, the ſalts with metallic baſes, we find moſt of thoſe that are corroſive, moſt ſoluble, deliqueſcent, leaſt cryſtallizable, moſt active upon other ſubſtances, and moſt eaſily to be decompoſed. The two intermediate claſſes with baſes of volatile alkali, and of earth, are alſo intermediate with regard to theſe properties.

Secondly, as the ſeveral acids are more or leſs ſimple and powerful, they form with the ſubſtances to which they are capable of uniting, neutral ſalts, the abſolute ſaturation of which is more or leſs perfect, according to the nature of the acid. Neutral vitriolic ſalts are the firſt in this reſpect, then nitrous and marine ſalts, or marine and nitrous ſalts; for theſe acids do not differ much; and, laſtly, acetous and tartareous ſalts.

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We ought to obſerve upon this ſubject of general conſiderations upon neutral ſalts, that we muſt not judge, from one or a few of their properties, concerning the degree of coheſion and of abſolute ſaturation of their principles, but from all their properties taken and compared together; becauſe poſſibly one of the principles of a ſalt may be abſolutely, or almoſt abſolutely, ſaturated, while the other principle may be far from this degree of ſaturation; and according as the acid or the baſe is moſt ſaturated, the properties of the neutral ſalt muſt vary conſiderably. For example; we ſhould be much miſtaken, if, upon conſidering that corroſive ſublimate is leſs ſoluble in water than common ſalt, and not at all deliqueſcent, as the latter ſalt is a little, we ſhould conclude, that the coheſion of the principles of corroſive ſublimate and their abſolute ſaturation are much ſtronger than in common ſalt. The corroſive quality of this ſalt, and its powerful action upon many bodies, which properties do not, or ſcarcely, exiſt in common ſalt, evidently prove the contrary. *See* SUBLIMATE (CORROSIVE).

We muſt alſo obſerve, that in many combinations of neutral ſalts, and particularly thoſe with metallic baſes, ſome metals and the acids themſelves ſuffer, by the very act of combination, certain alterations which have great influence on the nature of the neutral metallic ſalt reſulting from their union; for inſtance, although lunar and mercurial nitre be cryſtallizable, and little, if at all, deliqueſcent, while the nitres with baſes of copper and of iron are very much ſo, we muſt not thence conclude, that iron and copper ſaturate the nitrous acid leſs than ſilver and mercury do; becauſe we are certain that this difference does only proceed from this circumſtance, that while the nitrous acid diſſolves copper and iron, it decompoſes them, and deprives them of much of their inflammable principle which is neceſſary to the connexion of metals with acids, whereas it does not produce the ſame effect ſo evidently upon ſilver and mercury. Accordingly, the ſalts which reſult from the ſolution of copper and of iron by nitrous acid, ought not to be rigorouſly conſidered as combinations of theſe metals, but rather as combinations of their earth with this acid: for as nitrous acid quits ſilver and mercury to diſſolve copper and iron, probably if this ſolution could be made without loſs of the phlogiſton of theſe latter metals, they would more compleatly ſaturate this acid, and more firmly adhere to it, than the former metals.

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Many other considerations of this kind may be made concerning the different kinds of neutral salts; but the detail of them would engage us too long, besides that they will easily occur to those who would attentively reflect on this subject. We will however mention something concerning a discussion that has arisen lately betwixt some chemists relative to neutral salts.

Mr. Rouelle had advanced, in a Memoir of the Academy in 1754, that several of these salts may be in two different states; that is, they may be in a state of a perfect saturation, or, they may have an excess of acid. He cites for examples several combinations of metallic matters with acids, such as those of mercury with marine acid and with vitriolic acid, and that of bismuth with nitrous acid. Each of these metals may, according to him, form with the same acid two very different neutral salts, one of which has an excess of acid, and contains the largest possible quantity of acid; and the other is precisely saturated, and contains the smallest quantity possible of acid. This chemist cites also, as another instance of the same doctrine, the combination of a fixed alkali with an acid. It is that of the vegetable fixed alkali with vitriolic acid, forming consequently the neutral salt called *vitriolated tartar*. Mr. Beaumé has opposed this opinion in several Memoirs read at the Academy, and also in the Journal and Gazette of Medicine. He disputes the facts upon which Mr. Rouelle establishes his theory. He maintains, that many of the saline metallic combinations cited by Mr. Rouelle as examples, and considered by him as neutral salts containing the least possible quantity of acid, are nothing less than salts, but metals, deprived of all acid, when the acid which adheres superficially to the precipitated metal is sufficiently washed from it; and he thinks that Mr. Rouelle has been mistaken, from not having sufficiently washed these metallic precipitates which he considered as salts. Mr. Beaumé proves his opinion, by washing with a very large quantity of distilled and boiling water turbith mineral and mercurius vitæ; which precipitates he, by this method, deprived of every particle of acid.

With respect to the vitriolated tartar, the process by which Mr. Rouelle gives it an excess of acid is, by distilling in a retort two ounces of pure vitriolic acid upon this salt, till the salt is dry, and even till the retort has been kept red-hot during an hour. Mr. Rouelle observes, that when vitriolic acid is poured upon this salt, a considerable heat is excited, even when the salt has been deprived of the water of

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its cryſtallization by drying; and thence concludes, that the acid acts upon and combines with the ſalt. The ſaline maſs remaining after the diſtillation melts, and weighs, as Mr. Rouelle has obſerved, five ounces and one gros. This, according to him, is vitriolated tartar with exceſs of acid. He affirms alſo, that in this ſalt, as in all thoſe which are ſuſceptible of receiving exceſs of acid, there is a point of ſaturation of this exceſs of acid, and this point is marked in the preſent operation by the ceaſing of white vapors which riſe during the diſtillation. This vitriolated tartar with exceſs of acid has really an acid taſte; it attracts the moiſture of the air, reſolves into a liquor like the deliqueſcent ſalts, reddens the tinctures of violets and of turnſol, effervesces with fixed and volatile alkalis, and, laſtly, in cryſtallizing, remains acid.

Mr. Beaumé acknowledges almoſt all theſe facts; but he denies that we ought thence to conclude, that vitriolated tartar really contains an exceſs of combined acid. He ſupports his opinion upon the following facts and reaſons: Vitriolic acid diſtilled from pure ſand, in the ſame manner as Mr. Rouelle diſtilled that acid from vitriolated tartar, adheres to it in the ſame manner, although we are certain that it does not act upon ſand. In this therefore, and in many caſes, it is only an adheſion of juxta-poſition, which vitriolic acid is capable of contracting with any body from the degree of fixity which it has, eſpecially when perfectly concentrated.

In the ſecond place, the vitriolic acid, with which Mr. Beaumé affirms the vitriolic tartar is only ſuperficially covered, by Mr. Rouelle's proceſs, is ſo far from being truly combined, that it may be entirely ſeparated without fire, or any intermediate ſubſtances, by means purely mechanical: for by draining this ſalt very carefully upon brown paper, or even upon clean ſand, a vitriolated tartar perfectly neutral may be obtained, which preſerves the water of its cryſtallization, and conſequently the form and ſolidity of its cryſtals, and which no longer contains any veſtige of an acid. From theſe experiments Mr. Beaumé concludes, that this exceſs of acid in vitriolated tartar is not real, and is, like the unwaſhed metallic precipitates, miſtaken for ſalts with the leaſt poſſible quantity of acid, one of thoſe deceitful appearances againſt which we cannot too much guard. Mr. Beaumé generaliſes his propoſition concerning the exceſs of acid of vitriolated tartar, and affirms, that no neutral ſalt with baſis of fixed alkali either

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has an excefs of combined acid, or of combined alkali, although it be cryftallized in an acid or an alkaline liquor; and that the acid or alkali, with which thefe falts are mixed, when cryftallized in fuch liquors, is only interpofed betwixt their parts, and may always be carefully feparated from them folely by the mechanical method of imbibition.

The friends of M. Rouelle replied, that the means employed by M. Beaumé to feparate the fuperabundant acid were not ftrictly *mechanical*; for that the moifture of the air contributed to decompofe the acid vitriolated tartar, and to carry off its fuperabundant acid. M. Rouelle the younger maintains, that cryftals of tartar afford another unqueftionable inftance of a falt cryftallized with excefs of acid. *See Memoirs Eftrang. Tom.* VI.

We fhall not enter more particularly into thefe fubjects, which perhaps will hereafter be further illuftrated. We fhall only obferve, that if we were to examine thefe matters as well as they deferve, it feems effential to diftinguifh firft metallic falts from all others; for the greater or lefs degree of concentration of acids feems indifferent, with regard to the faline combinations which refult from the union of thefe acids with earths and alkalis both fixed and volatile; that is to fay, the fame quantity of acid remains united with the earths or alkalis, whether the acid employed be concentrated or diluted with water: but metals, efpecially fome certain metals, cannot be combined, or remain combined with acids, in the greateft poffible quantity, unlefs the acid employed be in a proper degree of concentration; fo that the fame quantity of the fame acid, which, when fufficiently concentrated, is capable of remaining united with a certain quantity of metal, can diffolve only a much lefs quantity of the fame metal, if this quantity of acid be diluted with a larger quantity of water.

This fingular phenomenon of metals relative to acids can be only attributed to the inflammable principle which enters into their compofition. Metals in general adhere only to acids by this principle, and not by their earthy principle, or at leaft much more by the former than by the latter: but on the other fide, the union of water with any body is an obftacle to the combination of that body with the inflammable principle. A quantity of acid, therefore, diluted with water, cannot be united but with a lefs quantity of metal than the fame quantity of acid when concentrated. This feems to be naturally deduced from the fundamental principles of chemiftry.

In the second place, we may remark, that after having distinguished metallic salts from all others, we ought also to distinguish the combinations of mercury and marine acid, and even the corneous metals, from all other metallic salts. These salts make a distinct class, and have a peculiar character. *See upon this subject the article* SUBLIMATE (CORROSIVE).

Notwithstanding the distinctions we have shewn between the different kinds of neutral salts, we are far from believing that they can be methodically distributed, from considering any of their common properties, or classed, as plants have been by botanists; because each of them has so many peculiar, and, at the same time, very essential properties, that the salts in the same class would often differ more from each other in their peculiar properties than they would be similar in their common property by which the class is characterised. A proof of this truth may be seen in a Memoir inserted in the Collection of the Academy for the year 1744, in which Mr. Rouelle has undertaken to class neutral salts according to their crystallization: for we find very different salts ranged not only in the same Section, but also under the same genus, as, for instance, *sal ammoniac*, and the *combination of lead with marine acid*. We do not mean to depreciate Mr. Rouelle's attempt upon this subject, or those of others in the same way, as we are convinced, that however unsuccessful these may be in their particular object, they must encrease our knowledge by the many experiments and observations which they require, and by the comparisons and new views they occasion. We need only to read the above Memoir of Mr. Rouelle to be convinced of this.

Neutral salts have many uses in chemistry, arts, and medicine; but as these uses depend upon the peculiar nature of each of them, we refer to the particular articles; and here we shall only say a little concerning their medicinal virtues.

We may observe, that these salts are antiseptic when mixed in a proper dose, that is, in a large dose, with substances capable of putrefaction. Each of them resists all kinds of fermentation more or less effectually: but the most exact experiments that have been made on this subject by Sir John Pringle, by the author of the Essay on Putrefaction, and by Mr. Gardane, physician at Paris, prove that these neutral salts, the principles of which are firmly connected, as all those with basis of fixed alkali, particularly common salt, rather accelerate than retard putrefaction. We find, from the experiments of the author of the Essay

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on Putrefaction, that the most powerful antiseptics among the neutral salts are those which are most astringent, as the neutral salts with metallic bases.

All neutral salts with bases of fixed alkali taken internally in the dose of an ounce or more, produce in general a very mild purgative effect; and in small doses, as of one or two gros, they are only aperitive.

Ammoniacal salts are given in small doses only. They are exciting, dividing, and antiscorbutic. The common sal ammoniac is the only ammoniacal salt now used.

Most of the salts with bases of calcareous earth are also considered as aperitive and dividing: but these salts differ much according to the nature of their acids. Thus selenitic salts are very different in their effects from nitrous and marine salts with calcareous bases. Of those salts, only the acetous, such as the salts of coral, pearls, &c. are employed, and these but very little in France.

All the salts with the metallic bases are corrosive, especially those containing mineral acids. Accordingly, they are not internally employed in medicine, excepting some of those with bases of mercury, iron, regulus of antimony. *See the articles* IRON, MERCURY, REGULUS *of* ANTIMONY, *and* TARTAR (EMETIC).

NEUTRAL ARSENICAL SALT.

This salt is a combination of arsenic with fixed alkali to the point of saturation. Mr. Macquer first discovered this combination, and began an account of its properties in the Memoirs of the Academy for the years 1746 and 1748. His method of making this salt is, by mixing together equal parts of very white crystalline arsenic and purified nitre, and by distilling this mixture in a retort with a graduated heat in the usual manner, till the retort is red-hot, and no more vapors of nitrous acid arise. In the retort a saline mass remains, white, compact, and fixed; from which, after solution in hot water, filtration, evaporation, and crystallization, may be obtained beautiful, quadrangular, prismatic crystals, terminated at each end by a quadrangular pyramid, the sides of which correspond with those of the prism.

Arsenic is known to have the property of decomposing nitre, and of very easily disengaging its acid; but, at the same time, it combines with the alkali of the salt, and saturates it precisely as an acid would do; so that the new salt which results from this operation, when well made, is exactly

exactly neutral, and gives no marks of an alkaline quality. It is infinitely more soluble in water than pure arsenic, and dissolves in a less quantity of hot than of cold water.

This salt is easily fusible by fire, and remains fused and transparent like glass, without being alkalised, if it has not touched any inflammable matter: for it may be easily decomposed by phlogiston which unites with the arsenic, separates it from the alkali, and is sublimed. No pure mineral acid can decompose this salt, because arsenic seems to have a greater affinity with fixed alkali than acids have: but when these acids are united with metallic matters, they then easily decompose the neutral arsenical salt, even by the humid way; so that a solution of this salt added to a solution of metals occasions a precipitate composed of the arsenic and metal, while the acid of the metallic solution combines with the fixed alkali of the neutral arsenical salt, and forms another neutral salt. Thus two decompositions are made, and two new combinations are formed.

The uses of the neutral arsenical salt are not yet well determined; yet as the arsenic seems, from the properties mentioned, to be strictly united with the fixed alkali, this salt may probably be usefully employed, 1. for the preparation of the regulus of arsenic; 2. to combine arsenic conveniently with metallic matters; 3. in the composition of many glasses; 4. as the corrosive mineral acids form very mild salts when saturated with alkali, we may be induced to believe that arsenic completely saturated with a fixed alkali, as it is in neutral arsenical salt, might form a very mild salt, which may be powerful in medicine; but the name of arsenic is so terrible, that it will probably be never tried: but if it should, very numerous and long trials ought to be previously made on animals.

This salt might probably be useful in arts; for Mr. Beaumé prepares large quantities of it for different manufacturers; but the uses to which it is applied are kept secret. *See* ARSENIC.

SALT *of* MILK.

Salt of milk is a neutral salt of a singular nature, and very little known. It is obtained from whey by evaporation and crystallization. As the evaporated whey from which it is obtained has a red color and a saccharine taste, that part of the salt of milk, which crystallizes first, has the same color and taste; and hence it has been called *sugar of milk*. If it be required more white and pure, it must be again

again diſſolved in pure water, and cryſtallized once or twice; and then it becomes very white, and has a farinaceous appearance even internally, although it is compact and hard. When thus purified, it is leſs ſaccharine, and has in general leſs taſte; becauſe it is diſengaged from the ſaccharine part of the milk, and even from a little common ſalt, which may afterwards be ſeparated from the whey.

Cryſtals of this ſalt ſeem to contain very little water: they have little taſte, and not deliqueſcent, nor very ſoluble, and ſeem to be difficultly decompoſed. They deſerve a farther examination.

Some perſons have imagined, that a liquor like whey might be made by diſſolving ſalt of milk in pure water; but this ſalt is only one of the conſtituent parts of whey; and conſequently the purer it is, the leſs can its ſolution imitate that liquor. *See* MILK.

SAL POLYCHREST.

The word polychreſt is applicable to things which have many uſes: accordingly chemiſts ſay, that a furnace is polychreſt when it is ſo conſtructed that different operations may be made with it.

For the ſame reaſon, the inventors of ſome ſalts have given them this epithet to denote their various powers in medicine. Hence we have the *ſal polychreſt of Glaſer*, which is a vitriolated tartar, made by the detonation of nitre with ſulphur; the *ſal polychreſt of Rochelle* or *of Saignette*, which is a tartareous ſalt, or a ſoluble tartar with baſis of marine alkali. *See* SALT *of* SAIGNETTE, *and* TARTAR (VITRIOLATED).

POTASH.

Potaſh is a purified, fixed, vegetable alkali, obtained from the aſhes of wood. *See* ALKALI (FIXED VEGETABLE).

SALT *of* SAIGNETTE *or of* ROCHELLE.

This ſalt is a ſoluble tartar with baſis of marine alkali, or a neutral ſalt formed by ſaturating the acid of tartar with marine alkali.

This ſalt was firſt compoſed for medicinal purpoſes, in imitation of ordinary ſoluble tartar or vegetable ſalt, by Mr. Saignette, apothecary at Rochelle, who brought it

into vogue, and kept it ſecret as long as he could. Meſſ. Boulduc and Geoffroy afterwards diſcovered, and publiſhed its compoſition.

To prepare this ſalt, cryſtals of marine alkali are to be diſſolved in hot water, and into this liquor powdered cream of tartar is to be thrown: when the effervelcence ceaſes, more cream of tartar is to be added, till the liquor is ſaturated: it is then to be filtered and evaporated; and very fine and large cryſtals may be obtained by cold, each of which is the half of a polygonous priſm cut in the direction of its axis. This ſection, which forms a face much larger than the reſt, is, like them, a regular rectangle, diſtinguiſhable however from the others, not only by its breadth, but alſo by two diſtinct diagonal lines which interſect each other in the middle.

Mr. Beaumé has obſerved, that the cryſtallization of this ſalt, and alſo of the vegetable ſalt, is much more eaſy and beautiful when the liquor in which it is made contains an exceſs of alkali, which does not prevent the ſalt from being exactly neutral, after it has been well drained.

Salt of Saignette has a ſaline taſte, moderately ſtrong, and diſagreeable. It retains much water in its cryſtallization, is ſoluble in a leſs quantity of hot water than of cold water, and conſequently cryſtallizes well by cold. It becomes farinaceous in a dry air, both from the quantity of water of its cryſtallization, and from the marine alkali which enters its compoſition. In other reſpects, it has all the general properties of *neutral tartareous ſalts*, or *ſoluble tartars*.

Salt of Saignette is uſed only in medicine. It is a good purgative, taken from an ounce to an ounce and a half. It is much uſed as ſuch, and is, for that purpoſe, diſſolved in pure water, or in ptiſans and mineral waters, to render them purgative. It is alſo given in ſmall doſes of one or two gros, as an alterative, aperitive, and corrector of other purgative ſubſtances. Although this ſalt really poſſeſſes theſe good qualities, it does not ſeem to differ much from ordinary ſoluble tartar, to which it is generally preferred. *See* TARTAR, ALKALI (MINERAL), *and* TARTAR (SOLUBLE).

SALES SALSI.

This is one of the names given to neutral ſalts, particularly to thoſe which have a taſte ſomething reſembling that of common ſalt. *See* SALT (NEUTRAL).

SEDATIVE SALT.

This salt is a saline, concrete, and crystallized substance, obtained from borax by means of acids. This matter, although it acts as an acid in borax, and perfectly saturates its alkali, has not an acid taste, nor the property of reddening the tinctures of violets and turnsol, as the acids properly so called do. Sedative salt has little taste and solubility in water. It is a kind of neutral salt, which has only some properties common to it with acids, as we shall afterwards see.

Sedative salt may be obtained from borax by sublimation, or by crystallization. The most common process for obtaining this salt by sublimation is that of Homberg, the discoverer of sedative salt. This process consists in mixing martial vitriol with borax, in dissolving them in water, in filtrating and evaporating the liquor till a pellicle appears: the liquor is then to be put in a small glass alembic, and the sublimation is to be promoted till only a dry matter remains in the cucurbit.

During this operation, the liquor passes into the receiver; but the internal surface of the capital is covered with a saline matter forming very small, thin, laminated crystals, very shining and very light. This is the sedative salt. The capital is then to be unluted, and the adhering salt swept off with a feather: the part of the liquor which passed last into the receiver is to be poured on the dry residuum of the cucurbit, and a new sublimation is to be promoted as before, by distilling till the matter in the cucurbit be dry: these operations are to be frequently repeated in the same manner, till no more sedative salt can be sublimed.

Sedative salt may be obtained by crystillization. For this purpose, let borax be dissolved in hot water; and to this solution, when filtrated, add any one of the three mineral acids, a little at a time, till the liquor be saturated, and even have an excess of acid, according to Mr. Beaumé's process: the liquor is then to be left in a cold place, and a great number of small, shining, laminated crystals will be formed: These must be washed with a little very cold water, and drained upon brown paper. This is the sedative salt obtained by crystallization. It is very beautiful and shining, but is somewhat denser than the salt obtained by sublimation. This latter is so light, that one gros is sufficient to fill a large phial.

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The acids, either of the martial vitriol, or the disengaged acids in the latter process, do only disengage this salt from the marine alkali with which it formed borax, as Mr. Baron has discovered. Accordingly, this salt, when well prepared, does not partake in any manner of the nature of the acid by means of which it has been disengaged. Sedative salt obtained by crystallization does not differ essentially from that which is sublimed, only that the crystals or laminæ of the latter are more separated and detached than those of the former.

Sedative salt, although it be thus sublimed, is not however volatile; for, as Mr. Rouelle observes, it only rises by means of the water of its crystallization. We know that when once it has lost its water by drying, it cannot be raised into vapors by the most violent fire, in which it remains fixed, and melts into a vitreous matter, as borax does.

This vitrified sedative salt preserves its saline character; and, although it has a beautiful crystalline appearance, it is only sedative salt deprived of all moisture and melted. It is entirely soluble in water, and may then be crystallized or sublimed, as at first, into its proper form.

A great quantity of water is required to dissolve sedative salt, and much more of cold than of boiling water. It may therefore be crystallized by cold, and is also crystallizable by evaporation alone.

Mr. Beaumé has made an interesting observation upon this method of disengaging and crystallizing sedative salt, which is, that we must add a little more acid to the solution than is sufficient for the saturation. He remarks, that when only the precise quantity of acid is added to decompose all the borax, the sedative salt remains confounded with the other saline matters contained in the liquor, and the crystallization is consequently disturbed. This inconvenience is avoided by the addition of a little more acid than is sufficient for the saturation of the alkaline basis of the borax. The sedative salt, although formed in a liquor thus acidulated, may be entirely deprived of an excess of acid, which is not combined with it, by means of draining upon paper, according to the principles of Mr. Beaume.

The acid that is mixed in the hot solution of borax decomposes this salt, becomes saturated with its alkaline basis, and instantly disengages the sedative salt; all which is effected without any effervescence. The sedative salt does not crystallize as soon as it is disengaged, although the

liquor be at the point of cryſtallization, when only the preciſe quantity of water is added which is neceſſary for the ſolution of the borax. The heat is the cauſe of this; for as ſoon as the liquor cools, a conſiderable quantity of cryſtals is perceived.

From the above-mentioned properties of the ſedative ſalt, by which it reſiſts fire, ſo as to be capable of vitrification, without being otherwiſe altered, we may perceive that it is a ſaline compound, the principles of which are ſtrictly united, and very difficultly ſeparable. This truth has been illuſtrated by numerous and accurate experiments on this ſubject by Mr. Bourdelin, related in the Memoirs of the Academy for the years 1753 and 1755.

From theſe experiments we find, that ſedative ſalt reſiſts the moſt powerful agents for the decompoſition of ſaline ſubſtances. It was unaltered by treatment with inflammable matters, with ſulphur, with mineral acids diſengaged, or united with metallic ſubſtances, and with ſpirit of wine. Mr. Bourdelin could only perceive ſome marks of an inflammable matter, and a little marine acid, in this ſalt. The former he diſcovered by a ſmell of ſulphureous acid communicated by it to vitriolic acid; and the latter by a white precipitate formed in a ſolution of mercury, by the liquor obtained from the diſtillation of a mixture of this ſalt with powder of charcoal. Mr. Bourdelin does not poſitively affirm the laſt propoſition; but acknowledges, with all chemiſts, that we do not know the nature of ſedative ſalt, from not having been able to decompoſe it.

As this ſalt has the property of diſengaging the acids of nitre and of common ſalt by uniting with their baſes, and alſo as it is very vitrifiable, and promotes the vitrification of other ſubſtances, moſt chemiſts believe that it is compoſed of vitriolic acid intimately combined with a fuſible and vitreſcible earth.

This is one of the ſalts which are ſoluble in ſpirit of wine, to the flame of which it communicates a green color. As only the ſaline combinations of copper are known to be capable of giving this color to the flame of ſpirit of wine, ſome chemiſts have been induced to believe, that ſedative ſalt might contain copper, or the calx of copper.

Laſtly, we may ſuſpect ſome analogy betwixt the ſedative ſalt, on one ſide, and arſenic and phoſphoric acid on the other, from ſome properties which each of theſe ſubſtances have, and particularly from their action upon certain ſalts, and from their vitreſcible quality. But theſe latter ſub-

ſtances

ſtances are not better known than ſedative ſalt; therefore all that we can ſay upon this ſubject is, that much yet remians to be diſcovered concerning all theſe matters.

Excepting the uſes of borax in vitrifications, and in fuſions and ſoldering of metals, ſedative ſalt is only employed in medicine. Homberg, its inventor, believed that he diſcovered in it a ſedative, antiſpaſmodic, and even narcotic quality, and thence called it the *narcotic ſalt of vitriol.*

It was generally employed in convulſive diſeaſes after the praiſes Homberg had beſtowed upon it; but its ſedative powers have not been well aſcertained. The beſt practitioners even affirm, that, to produce any effect, it muſt be given from half a gros to a gros, inſtead of doſes of a few grains, which were given at firſt. *See* BORAX. *(u)*

SALT *of* SODA.

This is one of the names given to marine or mineral alkali obtained from the aſhes of ſoda and of other maritime plants. *See* ALKALI (MINERAL).

SULPHUREOUS SALT *of* STAHL.

This name is given to a neutral ſalt, compoſed of volatile ſulphureous acid, combined to the point of ſaturation with fixed vegetable alkali.

(u) SEDATIVE SALT. Mr. Cadet has publiſhed, in the Memoirs of the Royal Academy of Sciences for the year 1766, an account of ſome experiments made by him upon borax and the ſedative ſalt. From theſe he infers, 1. That the acid contained in borax is the marine, he having made a corroſive ſublimate with this acid and the mercurius precipitatus per ſe. 2. That the ſedative ſalt does not exiſt in borax, but is produced during the proceſs. 3. That this ſedative ſalt is compoſed of the marine acid originally exiſting in the borax, of the vitriolic acid employed in the operation, and of a vitreſcible earth. 4. That this vitreſcible earth is the ſame as that which is generally ſeparated from borax during its ſolution in water, and which abounds more in the unrefined than in the refined borax. 5. That this earth conſiſts of a calx of copper, from which, by reduction, he obtained a regulus of copper. 6. That borax therefore is compoſed of a calx of copper united with marine acid, and with mineral alkali. The ſame chemiſt purpoſes to make further experiments on this ſingular ſalt. But M. Beaumé maintains that the copper is only accidental in borax, and proceeds from the veſſels uſed in the preparation of this ſalt; but that no copper can be obtained from pure borax.

This ſalt may be made either by ſaturating fixed alkali with volatile ſulphureous acid made in a cracked retort, in Stahl's manner, or by expoſing linen ſoaked in liquid fixed alkali to the vapors of ſulphur ſlowly burning. When this latter method is employed, the linen dries, becomes ſtiff, and ſhines with many ſmall needle-like cryſtals, which are the ſulphureous ſalt.

Volatile ſulphureous acid does not differ from pure vitriolic acid but by a portion of phlogiſton, which is only weakly united with it, but is however ſufficient to diſguiſe conſiderably the eſſential properties of this acid. Sulphureous vitriolic acid has not only a pungent ſmell and volatility which the pure vitriolic has not, but it alſo forms with different ſubſtances, particularly with fixed alkali, neutral ſalts very different from thoſe formed by the union of theſe ſubſtances with pure vitriolic acid. Stahl firſt obſerved this ſalt, which is the only one known of all the combinations of the ſulphureous acid.

This ſulphureous ſalt has a more pungent taſte than vitriolated tartar, is more ſoluble in water, and is cryſtallizable by cold. Its cryſtals are like needles attached to each other by their ends, forming tufted cluſters of cryſtals; in which reſpect alſo it differs from vitriolated tartar, and is ſomewhat analogous to nitre.

This ſalt may be decompoſed by any acid, and its ſulphureous acid expelled from it. Thus vitriolic acid, from being naturally the ſtrongeſt of any, is rendered the weakeſt of all, merely by union with the inflammable principle, which is only weakly combined with it.

The natural volatility of the phlogiſtic principle, and its weak adheſion to the volatile ſulphureous acid, occaſion a gradual change of the nature of the ſulphureous ſalt. This ſalt is perpetually changing, from the conſtant diſſipation of its phlogiſton. It gradually loſes its peculiar properties by which it differs from vitriolated tartar, becomes more and more ſimilar to this ſalt, and at laſt, when it has loſt all to its phlogiſton, does not in many reſpects differ from it. Probably we might obſerve the ſame changes in the combinations of ſulphureous acid with other ſubſtances; nevertheleſs thoſe which, like metals, have a ſtronger affinity with phlogiſton than alkali has, may perhaps produce effects very different.

All the phenomena of the ſulphureous ſalt, of the volatile ſulphureous acid, and of ſulphur, with regard to their ſeveral combinations, are naturally deducible from this general

general principle, that the affinities of the moſt compound bodies are always weaker than thoſe of the moſt ſimple ſubſtances. *See* VOLATILE SULPHUREOUS ACID, *and* ACID (VITRIOLIC).

FEBRIFUGAL SALT *of* SYLVIUS.

This is a neutral ſalt compoſed of marine acid ſaturated with fixed vegetable alkali. It is alſo called *regenerated ſea ſalt*, but improperly, becauſe the baſis is different from that of ſea ſalt, excepting its taſte, which is not ſo agreeable as that of ſea ſalt. It reſembles this ſalt in its cryſtallization, and in moſt of its eſſential properties. It does not ſeem to deſerve the epithet *febrifugal*, although it may, when given in proper doſes, as a purgative and antiſeptic, contribute to the cure of ſome fevers, which qualities are common to it with other neutral ſalts. It is not now employed. *See* ACID (MARINE), ALKALI (FIXED), *and* NEUTRAL SALTS.

SALTS *of* TAKENIUS.

The ſalts prepared in Takenius's manner are impure fixed alkalis, obtained from the aſhes of vegetables burnt for that purpoſe in a peculiar manner, namely, by ſuffocating their flame; and leaving no more communication with the air than is ſufficient for the burning of their moſt diſengaged inflammable parts.

When therefore we would prepare the fixed ſalts of a plant according to this method, the dried plant is put in an iron pot, which is to be heated ſo that its bottom ſhall be red. The plant muſt be continually ſtirred; a thick fume will exhale from it, and at length a flame riſes. The pot is then to be covered with a lid, which muſt be ſo looſe that the flame only will be extinguiſhed, and the ſmoke will paſs out. The lid muſt be taken off ſometimes, that the plant may be ſtirred. When the plant is by this method reduced to a kind of aſhes, theſe aſhes muſt be lixiviated with boiling water; and when the lixivium has been evaporated to dryneſs, a ſaline matter more or leſs reddiſh will remain, which ought to be kept in a bottle. This is the fixed ſalt of the plant prepared in Takenius's method.

By burning plants in this manner, the fixed alkali obtained is evidently phlogiſticated, rendered ſemi-ſaponaceous, ſimilar to that which is prepared for the making of

Pruſſian blue, and mixed with all the neutral ſalts contained in the plant. Theſe impure alkalis have been intended only for medicinal uſes. Some perſons have imagined that they could retain much of the virtue of the plant from which they have been obtained. But although we do not doubt that the fixed ſalts of different plants, prepared in this method, differ conſiderably from each other; yet as the medicinal virtues of vegetables depend chiefly on their proximate principles, and as theſe principles are totally changed, and decompoſed by burning, even when they are made with the precautions which Takenius mentions, theſe ſalts retain none of the virtues of the plants from which they are produced when alkalis are required. They are only ſemi-ſaponaceous fixed alkalis, much leſs cauſtic than well purified alkalis, and therefore may be preferred in medicine. Theſe alkalis partake beſides of the virtues of the neutral ſalts with which they are mixed.

SALT *of* TARTAR.

This name is commonly given to the fixed alkali of tartar, and even frequently to fixed vegetable alkali in general. *See* ALKALI (FIXED).

VEGETABLE SALT.

This ſalt, called alſo *ſoluble tartar*, and *tartariſed tartar*, is a combination to the point of ſaturation of cream of tartar, or acid of tartar with fixed vegetable alkali. It is prepared and cryſtallized like ſalt of Saignette, from which it differs in its alkaline baſis. The cryſtals of this ſalt are much ſmaller than thoſe of ſalt of Saignette. In other reſpects it has the ſame properties, chemical and medicinal. *See* SALT *of* SAIGNETTE, TARTAR, *and* TARTAR (SOLUBLE).

SALT *of* VINEGAR.

The ſalt ſold by apothecaries under this name is nothing but vitriolated tartar, impregnated with very ſtrong radical vinegar.

As pure radical vinegar cannot be obtained in a concrete ſtate but with very great difficulty, and as it does not retain this concrete ſtate when it has once received it, as the Count de Lauraguais has ſhewn, when a ſalt of vinegar is required with a very pungent and penetrating ſmell, to be kept

kept in bottles, like the concrete volatile alkali called salt of England, a better expedient has not been found than that we have mentioned. This mixture has a smell of radical vinegar, almost as pungent as that of volatile alkali, although the kind be very different; and is applicable to the same purposes, namely, to relieve hysterical paroxysms. *See* VINEGAR.

VOLATILE SALTS.

This name is frequently given to volatile, concrete alkaline salts. Thus *volatile sal ammoniac*, and *volatile salt of hartshorn*, are the volatile alkalis obtained from these substances. Nevertheless, the same name is sometimes given to other saline substances of very different natures, for instance, *the salt of amber*, which is acid, and is called *volatile salt of amber*, which is certainly an inconvenience. The appellation *volatile salt* may be given to all saline matters really volatile, that is, which may be sublimed with a moderate heat. But as these salts are of very different kinds, they ought to be distinguished by some more particular name. The volatility of salts is a very indeterminate quality. For of those which are considered as such, some are much more, and some much less volatile than others.

These salts are called *semi-volatile* which cannot be sublimed without a fire sufficient to render the bottom of the vessel containing them red-hot, such as most ammoniacal salts, sweet mercury, and some others. And those are called *fixed salts*, which may be kept red-hot during a certain time without sensible loss. But, rigorously speaking, no salts are absolutely fixed; for, as we have said elsewhere, the alkalis called fixed, and the other salts which are considered also as fixed, are dissipated in fume when long exposed to a violent fire, with access of air. *See* ALKALIS (VOLATILE), FIXITY, VOLATILITY.

URINOUS SALTS.

This name was given by ancient chemists to all alkaline salts, volatile or fixed; to the former, because they all have the taste of putrefied or distilled urine; and to the fixed, because although they have not themselves this taste, they however occasion it, when applied to the tongue, by disengaging the volatile alkali contained in animal substances. Therefore *urinous salts* and *alkaline salts* are synonimous. *See* ALKALI.

SALT

SALT *of* STEEL.

Some chemifts have given this name to feveral combinations of iron with acids, even to martial vitriol, as appears from *Riverius's* *falt of fteel*, which is a martial vitriol made with iron, vitriolic acid, and fpirit of wine. *See* VITRIOL.

SALT-PETRE. *See* NITRE.

SAND. Sand is compofed of fmall ftony matters. The kinds of fand may therefore be as many as the kinds of ftones. Moft fands confift of different kinds of ftones mixed together. But as foft ftones are eafily reducible into fo fmall particles, that they are more like powders or earths than fand; and as the molecules of hard or vitrifiable ftones are capable of preferving longer their fize; hence moft matters called fand are of the nature of vitrifiable earths. *See* EARTHS (VITRIFIABLE). Accordingly, by the name of fand, we underftand always, in natural hiftory and in chemiftry, a matter of the nature of vitrifiable earths.

The principal ufe of fand in chemiftry is in compofitions for pottery and glafs. Some fands are more and fome lefs fufible. The particles alfo of fome are larger than thofe of others. The finer kind is generally ufed for vitrifications, and other chemical operations, becaufe it is naturally much divided: It is frequently employed to make a *fand-bath* to tranfmit heat to veffels placed in it.

SANDARACH. This is a yellow or red combination of arfenic with fulphur. *See* ARSENIC, *and* REALGAR.

SANDIVER. *See* GLASS-GALL.

SAPHIRE. *(x)*

SARCOCOLLA. *(y)*

SARSAPARILLA. *(z)*

(x) SAPHIRE is the name of a pellucid blue gem, the hardnefs of which is next to that of the ruby. By fire it is unfufible, but its color is thereby deftructible. It may be imitated by fufing a hundred parts of cryftal glafs-fritt with one part of zaffre, and a very fmall proportion of manganefe.

(y) SARCOCOLLA is a gum-refin, of an ounce of which fix drams were found to be foluble by fpirit of wine; and feven drams and a half were found to be foluble by water. *Neuman.*

(z) SARSAPARILLA. From fixteen drams of this root Neuman obtained by water fix drams of gummy extract, and from an equal quantity he obtained by fpirit four drams of refinous extract.

SAS-

SASSAFRAS. (a)

SATURATION. All the particles of matter have, as is ſaid under the articles AFFINITY, COMBINATION, SOLUTION, *and* GRAVITY, a tendency to unite one with another. In fact, when they are united, and when this tendency is ſatisfied, it is called the ſtate of *ſaturation*, and then the whole effect of this tendency, or of this force, conſiſts in making them cohere together. But all the phenomena of chemiſtry ſhow, that the tendency to union of the parts of different ſubſtances is more or leſs ſtrong, according to the nature of theſe ſubſtances. Hence the parts of two ſubſtances may be united together with all the force of which they are ſuſceptible, reſpectively to each other, although their tendency to union in general be very far from being entirely exhauſted and ſatisfied.

This remark leads us to conſider ſaturation in two views, that is, that we ſhould diſtinguiſh the ſaturation of one ſubſtance relatively to another, from the greater or leſs diminution of tendency to union in general, which a ſubſtance has ſuſtained by means of any particular union contracted. This latter we ſhall call *abſolute ſaturation*, and the former *relative ſaturation*.

Theſe things being premiſed, as the general tendency to union diminiſhes always in proportion to the force with which the parts are united, hence the adheſion more or leſs ſtrong, contracted betwixt the principles of any compound, influences much the nature and eſſential properties of this compound; for example, when the principles of a body are capable of uniting together with all their general tendency to union, their relative ſaturation is then confounded with their abſolute ſaturation, ſo that after their union, no tendency to new unions can be perceived in theſe bodies, or in any of their principles. Such are the neutral ſalts compoſed of mineral acids and fixed alkali. So ſtrong an union is contracted by the acid and alkaline principles of theſe ſalts, that they loſe entirely, or almoſt entirely, their taſte, cauſticity, activity; in a word, all the properties

(a) SASSAFRAS. The wood of this tree contains the heavieſt of all known eſſential oils. Of this oil Hoffman obtained an ounce and ſix drams from ſix pounds of the wood; and Neuman obtained from an equal quantity of wood, two ounces. From an ounce of ſaſſafras four ſcruples of extract were obtained by means of rectified ſpirit; and from an equal quantity of the wood two drams were extracted by water. *Neuman.*

which

which before this union were occaſioned by their general tendency to combination. Accordingly, the relative ſaturation of theſe is very diſtinct, and is one of the firſt which has been obſerved.

When, on the contrary, the principles of a compound can contract together only a weak union, and conſequently do not exhauſt by this union all their general tendency to combination, not only their point of relative ſaturation is leſs diſtinct, but alſo theſe principles, although relatively ſaturated by each other, are far from abſolute ſaturation, and ſtill preſerve, notwithſtanding this union, much of their diſſolving power. Compounds of this kind are always conſiderably active, and even cauſtic according to the nature of their principles. Such are deliqueſcent ſalts, and particularly moſt ſalts compoſed of mineral acids and metallic ſubſtances, the cauſticity of which cannot be otherwiſe explained. *See the articles* CAUSTICITY, *and* SUBLIMATE (CORROSIVE).

Many ſubſtances have a determinate and conſiderably diſtinct point of relative ſaturation, although they contract together but a weak union. But if we attend, we ſhall perceive that all theſe ſubſtances poſſeſs but a ſmall quantity of diſſolving power, or a weak general tendency to combination. Their relative ſaturation is nearly equal to their abſolute ſaturation. Such are ether with water, eſſential oils with ſpirit of wine, and moſt neutral ſalts with water. If we mix together and agitate good ether with water, a part of the ether unites with the water, nearly in the proportion of one to ten; ſo that if one part of ether be added to ten parts of water, all the ether diſappears by being diffuſed through the water, as the Count de Lauraguais obſerves. If the quantity of ether be more than one tenth part of the water, the overplus will float diſtinct upon the ſurface of the water, like an oil.

Alſo well rectified ſpirit of wine can only diſſolve a determinate quantity of each kind of eſſential oil, which quantity varies according to the kind of oil, and to the ſtate in which it happens to be. In general, the more attenuated they have been by rectification, the more they are removed from a reſinous ſtate, and the ſmaller quantity of them is ſoluble. And alſo the more highly rectified a ſpirit of wine is, the larger quantity of oil it diſſolves.

Water is the proper ſolvent of neutral ſalts. It is capable of diſſolving any of them, but moſt of them only in a certain quantity: and this point of ſaturation of water differs

with

with different ſalts, and degrees of heat applied. The point of ſaturation is moſt diſtinct with thoſe ſalts which contain a ſmall quantity only of the water of cryſtallization, and which are nearly equally ſoluble in hot and in cold water. Such are vitriolated tartar, and, ſtill more, common ſalt.

When the water is once ſaturated with theſe kinds of ſalts, the ſtrongeſt and longeſt boiling does not diſſolve a grain more, and the overplus of the ſalt remains entire at the bottom of the boiling water: But boiling water diſſolves an equal, or even an unlimited quantity of ſome ſalts, chiefly of thoſe which contain much water in their cryſtallization, ſuch as Glauber's ſalt, alum, borax, martial and cupreous vitriols, and others of that kind. The water of cryſtallization of theſe ſalts is alone ſufficient to keep them diſſolved, by means of heat. Hence, when they are expoſed to fire without water, they ſuffer a liquefaction, which is very different from fuſion, and is nothing elſe than a ſolution of the ſalt in the water of its cryſtallization, and conſequently laſts only till this water be evaporated. The point of ſaturation of water for theſe ſalts ſeems to be indeterminate.

Many ſubſtances are capable of uniting without being preciſely ſaturated, ſuch as water with any of the following ſubſtances; fluor acids, fixed vegetable alkali, fluor volatile alkali, moſt of the very deliqueſcent neutral ſalts, and ſpirit of wine. Such alſo are almoſt all metals uniting with each other: Although many of theſe ſubſtances have a great affinity together, as the fluor acids and alkalis with water, yet all their general tendency to combination is not exhauſted in theſe kinds of union. On the contrary, their union is little elſe than a very accurate and intimate mixture. Their diſſolving power is not ſatisfied by ſuch an union, but is almoſt entirely preſerved. We need not therefore be ſurpriſed, that no preciſe or determinate point of ſaturation is obſerved betwixt theſe ſubſtances. We may ſay, in general, that the point of relative ſaturation is ſo much more exact, diſtinct, and determinate, as the bodies which unite together have a ſtronger affinity, as they more compleatly exhauſt upon each other their diſſolving power, or as their relative ſaturation is more nearly equal to their abſolute ſaturation.

The examination of the ſeveral degrees of ſaturation which ſubſtances may ſuſtain by combining together, is an object as important as it is new in chemiſtry. This matter has

has been scarcely begun, and yet it well deserves the attention of chemists, as it would greatly advance the science. We could not treat this subject more fully without repeating what has been said elsewhere. We therefore refer to the articles *affinity*, *combination*, *composition*, *solution*, *causticity*, *gravity*, *salts*, *neutral salts*, *corrosive sublimate*; and several others.

SAUNDERS. (*b*)
SCAMMONY. (*c*)
SCORDIUM. (*d*)
SEA-WATER. *See* WATER.

(*b*) SAUNDERS. The wood of the tree, called *red saunders*, contains a red coloring material used in dying. Its color resides wholly in a resinous matter, and hence is extractable by spirit of wine, and not by water. The red color of Saunders, imparted to spirit of wine, becomes, by diluting the tincture with more spirit, yellow. The resin gave a deep red color to oil of lavender, and a pale red to oil of almonds and to oil of aniseeds, but no color to oil of amber and to oil of turpentine. The wood of the tree, called *yellow saunders*, is from its fragrance sometimes employed as a perfume. From sixteen ounces of the rasped wood, digested some days in salt water, two drams of essential oil were obtained by cohobation. Two drams of gummy extract may be obtained from two ounces of the wood by water; and from an equal quantity of wood, two drams and a half of resinous extract may be obtained by rectified spirit. *Neuman.*

(*c*) SCAMMONY is a gummy-resinous juice, which exsudes from the root of a species of convolvulus, in which incisions are purposely made at a certain season of the year. An ounce of Smyrna scammony yielded with water half an ounce of gummy extract, and the residuum yielded with spirit two drams of resin, leaving two drams of impurities undissolved. By applying rectified spirit at first to an ounce of the same scammony, two drams and two scruples of resinous extract were obtained; and from the residuum, water extracted half an ounce of gum, the indissoluble part amounting here to four scruples only. *Neuman.*

(*d*) SCORDIUM. An ounce of the dried leaves of scordium yielded with water four drams and a half of gummy extract, and afterwards with rectified spirit fifteen grains of resin. Another ounce, treated first with spirit, gave three drams of resinous extract, and afterwards with water, five scruples and a half of gum. A tincture, made in highly rectified spirit of wine, contains more of the active and less of the mucilaginous parts of this plant, than one made with a weaker spirit.

SELENITES. Modern chemiſts give this name to a ſort of neutral ſalt formed by the union of vitriolic acid with any calcareous earth. Vitriolic acid and calcareous earth are capable of combining together to the point of ſaturation in the moſt intimate manner. Probably a very conſiderable quantity of earth enters into this combination, at leaſt if we judge of it by the ſaturation of vitriolic acid, which appears to be more compleat than in any of the other neutral ſalts formed with this acid. This truth is ſufficiently eſtabliſhed by the properties of ſelenites.

Nature furniſhes us with a very large quantity of ſelenitic matters. Chemiſts agree that all gypſums or plaſter-ſtones, alabaſters, and gypſeous ſpars, are nothing elſe than ſelenites; but theſe ſubſtances are in large quantities within and upon the earth. We may alſo artificially compoſe ſelenites, by combining vitriolic acid to the point of ſaturation with calcareous earth. To effect this ſaturation eaſily, the calcareous earth muſt be in fine powder, the acid muſt be diluted in a very large quantity of water, and more earth muſt be added than is neceſſary for the ſaturation. Selenites may alſo be conveniently made by ſaturating lime-water gradually with weak vitriolic acid; or, laſtly, by pouring this acid into a ſolution of nitrous or marine ſalts with calcareous baſes. In theſe latter operations the ſelenitic ſalt renders the liquor turbid, and is precipitated.

Selenites, natural or artificial, when well waſhed from all exceſs of acid or other extraneous matter, has a ſlightly nauſeous taſte, which is ſcarcely perceptible but by drinking a glaſs of water impregnated with it, like that of the wells in and near Paris, the ſweetiſh and ſlightly nauſeous taſte of which is well known.

This earthy ſalt is one of the leaſt ſoluble by water of all the known neutral ſalts. Seven or eight hundred parts of water are required to diſſolve one part of ſelenites, excepting when its principles are combined, and the ſalt formed in the water, as Mr. Beaumé has obſerved; for then the water may diſſolve four or five times as much. By a ſlow evaporation it cryſtallizes, and forms thin laminæ, and retains in its cryſtallization a very ſmall quantity of water.

When it is expoſed to a moderate fire, it eaſily loſes this water of its cryſtallization, with its tranſparency and coheſion of its parts, and is reduced to a white powder.

With

With a very great fire, it is not fusible when alone, *(e)* but is more easily fusible than pure calcareous earth, by the addition of fluxes, as sand, and clay, and vitrifying salts. It resists the greatest heat without losing its acid. It cannot be decomposed by phlogiston, by alkalis fixed or volatile; and by metallic solutions in nitrous acid, by means of a double affinity. Thus the solution of mercury readily shews whether a water be selenitic or not, by forming a precipitate of turbith-mineral when added to such waters. As selenitic matters are copiously diffused, and almost every where within the earth, most waters of wells, or rivers, contain a greater or less quantity of selenites dissolved in them, as we may easily find by the abovementioned method of trial.

Nothing better shews the extreme difference betwixt vitriolic and other mineral acids, than the comparison of the saline properties of selenites with those of nitrous and marine salts with calcareous bases. The earthy basis is the same in these three salts; but the two latter have a violent, almost caustic taste, and are surprisingly deliquescent; while the first salt is very difficultly soluble in water, and almost insipid. The cause of these differences is, that vitriolic acid is more simple than the other acids, and is therefore capable of being more intimately combined and saturated with calcareous earth.

This kind of salt has been called selenites, probably because naturalists found its saline properties so weak, that they thought it ought to be distinguished from other neutral salts by a peculiar name. Perhaps they did not even believe it to be saline; for the nature of selenitic matters has been discovered but lately by experiments of modern chemists.

We are not enough acquainted with calcareous earths to know if selenites be of different kinds, or if all the substances to which this name is given are only one and the same salt under different forms of crystallization. If the kinds of calcareous earth be essentially different, they must form with vitriolic acid several kinds of selenites also essentially different from each other. But if only one kind of calcareous earth exists, then it can only form one kind of selenites.

(e) From Mr, D'Arcet's Memoir upon the effects of a violent and long-continued heat, we find that all gypseous stones, and all the artificial selenitic salts, are fusible and vitrescible by violent fire.

We may observe, that amongst the various bodies called by chemists selenites, that is, compounds of vitriolic acid with calcareous earths, some differ much from others, at least externally. These substances are all the gypsums, alabasters, and spars, which some chemists, particularly Mr. Pott, have called gypseous, and, lastly, some crystallizations and stalactites, which have the same principles and the same essential properties as other selenitic substances. *See* ACID (VITRIOLIC), ALABASTER, GYPSUM, SPAR, *and* EARTH (CALCAREOUS).

SEMI-METAL. Substances possessing all the metallic properties, excepting fixity and ductility, are called *semi-metals*. Thus every matter possessed of metallic density, opacity, and lustre, which is incapable of uniting with earths, but which is also brittle and frangible by the stroke of a hammer, and capable of being sublimed or reduced into vapors by fire, is a semi-metal. Hitherto we know but five semi-metals, which are *regulus of antimony*, *zinc*, *bismuth*, *regulus of cobalt*, *and regulus of arsenic*.

Some chemists have numbered mercury amongst the semi-metals, under pretence that it possessed all the metallic properties excepting fixity and ductility: but all semi-metals are combustible, and mercury is no more so than the perfect metals; and also, the want of ductility is falsely imputed to it, since the Academicians of Petersbourg, who some years ago fixed it, found it ductile and malleable. If mercury then be not ductile in its ordinary state, the cause of this appears to be, that it is really in fusion: but the most ductile metals lose their ductility by fusion, as this quality necessarily implies solidity. On the other side, the great volatility of mercury does not allow us to class it among metals. This metallic substance is therefore single in its kind, and is really neither a metal nor a semi-metal. *See* MERCURY.

Mr. Cronstedt has given, in the Memoirs of the Swedish Academy for the year 1751, a description of a new semi-metal: but this metallic substance is hitherto but little known. *(f)*

(f) Concerning this new semi-metal discovered by Mr. Cronstedt, *see the article* NICKEL. *See also a note to the article* METALS, concerning another new semi-metal which Mr. Justi says that he has discovered in the yellow mica.

SENA. (g)

SENEGAL (GUM) (h)

SERPENTINE-STONE. (i)

SILK. (k)

SILVER. Silver, called alſo *luna* by chemiſts, is a perfect metal, of a ſhining white color.

Its ſpecific gravity is, although conſiderable, nearly one half leſs than that of gold. It loſes in water an eleventh part of its weight. A cubic foot of ſilver weighs 720 pounds.

The tenacity of its parts is alſo nearly one half leſs than that of gold; a ſilver wire, the diameter of which is $\frac{1}{10}$ part of an inch, can ſupport only a weight of 270 pounds without breaking.

This metal is, next to gold, the moſt ductile of all. Very fine wire and leaf may be formed of it.

It is ſomewhat ſonorous and harder than gold, as Juncker obſerves; and is fuſible with a leſs degree of heat than gold is, according to Cramer. It ſeems to be as fixed and indeſtructible as gold is. Kunckel kept ſilver and gold in a

(g) SENA. An ounce of the leaves of Sena, treated with freſh parcels of rectified ſpirit of wine, yielded two drams and twenty-three grains of reſinous extract; and afterwards with water, two drams and two ſcruples of gummy extract, three drams and three grains remaining undiſſolved. Another ounce, treated firſt with water, gave four drams and half a ſcruple of gummy, and afterwards with ſpirit only, twenty-eight grains of a reſinous extract, which appeared to contain ſome groſs oily matter; and hence was difficultly reduced to dryneſs. The reſiduum weighed three drams and a ſcruple. Water diſtilled from Sena poſſeſſes the peculiar ſmell of theſe leaves, but no eſſential oil appears. The activity of Sena is greatly weakened by evaporation, eſpecially if the proceſs be performed in an open veſſel with a boiling heat. *Neuman.*

(h) SENEGAL (GUM) is a gum, almoſt pure, and entirely ſimilar in properties to the other pure gums, as gum arabic, cherry-tree and plum-tree gums. *See* GUM.

(i) SERPENTINE STONE is a ſteatites variouſly colored, but in which the green color generally predominates. *See* STEATITES.

(k) SILK is an animal ſubſtance, from 16 oz. of which may be obtained, by diſtillation, nine ounces of mixed matters, containing four ounces and two drams of urinous ſpirit, three ounces ſix drams of volatile ſalt, and one ounce of empyreumatic oil. The caput mortuum weighed ſeven ounces, and loſt an ounce on being calcined to whiteneſs. By elixating the calx, forty grains of fixed ſaline matter were alſo obtained. *Neuman.*

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the surface of this metal is apt to tarnish,
become black, by the contact of the phlo-
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cause it has the property of impregnating itself
e inflammable principle superabundantly, even in
d, like some other metallic matters; but silver seems
more susceptible of this effect than any other metal.

All acids are, with more or less facility, capable of dis-solving silver.

Vitriolic and marine acids may be combined with silver in its metallic state; but difficultly, and by particular ma-nagement.

To dissolve silver directly, vitriolic acid must be much concentrated and very hot; and therefore distillation is necessary, as in the operation of turbith mineral. *See* Tur-bith Mineral.

The marine acid cannot attack silver directly; but when it is very much dephlegmated, and, as it were, in a dry state, considerably hot and reduced to vapor, as is done by the royal cement in *concentrated parting*. *See* Parting (Concentrated).

But silver may be combined with the above-mentioned acids, by methods much more simple and convenient, which we shall describe, after having spoken of the solu-tion of silver by nitrous acid.

Nitrous acid, very pure and moderately strong, dissolves silver in its metallic state with the greatest facility. This solution is made spontaneously without heat, or with a very gentle heat at first; and when the silver has begun to dis-solve, the heat ought to be discontinued, to prevent the so-

lution from being too violent, especially if the quantities operated upon be considerable.

By this method nitrous acid may be saturated with silver; and if it be strong, it will dissolve a considerable quantity of that metal.

If the silver thus dissolved be allayed with copper, the solution will be green, and will preserve this color. If it contain no copper, the solution is at first greenish, which color gradually dissipates, and at last the liquor becomes quite white.

The surface of the silver begins to become black as soon as the acid makes impression upon it. This blackness proceeds from a part of the phlogiston of the nitrous acid, which is applied superabundantly to the surface of the silver.

Black flocks are frequently seen floating in this solution, which are insoluble by nitrous acid, and precipitate to the bottom. These flocks may be a small quantity of gold from which silver is seldom entirely free, or of some other phlogisticated substance, insoluble in nitrous acid.

The solution of silver by nitrous acid is more acrid and corrosive than pure nitrous acid; which property is very remarkable, and is common to it with several other combinations of metals. *See an explanation of this property under the article* CAUSTICITY.

This solution of silver corrodes all vegetable and animal matters, and stains the skin of a black color, which cannot be effaced till the blackened part be abraded. This blackness can be only attributed to the phlogiston of corroded matters, which unites superabundantly with the silver of the solution employed.

If a solution of silver by nitrous acid be sufficiently evaporated, and left to cool, a large quantity of white crystals will be formed in it, like scales, which are commonly called *crystals of silver*. These crystals are a nitrous salt, the basis of which is silver; for which reason it may also be called *nitre with basis of silver*, or *lunar nitre*.

This salt is fusible with a small heat, and easily loses the water of its crystallization. It becomes black, congeals by cold, and is capable of being moulded. It is then the famous cautery used by surgeons, and known by the name of *lapis infernalis*. *See the words* PARTING, CRYSTALS *of* SILVER, *and* LAPIS INFERNALIS.

Lunar nitre deflagrates upon coals almost as well as the nitre with basis of fixed alkali, which shews a strong adhesion

fion of nitrous acid with filver. Neverthelefs, this falt expofed to ftrong fire in diftilling veffels, or in a crucible, may be eafily decompofed. The acid quits the filver, and appears in its former ftate.

Although filver, as we have feen, is more eafily foluble in nitrous acid than in vitriolic and marine acids, we ought not thence to conclude, that this metal has, with the nitrous acid, a greater affinity than with the two others. On the contrary, the two latter acids are capable of feparating it from the nitrous acid, after this has diffolved it.

If vitriolic acid be poured into a folution of filver in nitrous acid, and if it be not diluted in too great a quantity of water, we fee immediately the liquors become turbid, and a white precipitate appears, which is nothing elfe than a new combination made of the filver which quitted the nitrous acid to unite with the vitriolic acid, and to form with it a new falt with metallic bafis. This falt, which may properly be called *vitriol of filver*, or *lunar vitriol*, is cryftallizable, and actually does cryftallize in the very inftant of precipitation; but the cryftals are fo fmall, from the rapidity of the cryftallization, that they have only the appearance of a white powder. They cannot be difcovered to be cryftals but by means of a good magnifying glafs.

The fame event happens, if, inftead of vitriolic acid, a folution of any falt containing that acid be added to a folution of filver in nitrous acid. The nitre of filver will be thereby decompofed, and a vitriol of filver obtained fimilar to the former.

Although vitriolic acid engaged in any bafis, fuch as fixed alkali, with which it has a ftronger affinity than with filver, does neverthelefs quit its bafis to combine with this metal, yet we may obferve, that in thefe precipitations two decompofitions and two new combinations are always effected, by means of a double affinity. We may therefore fee the explanation of this cafe at the word AFFINITY.

Marine acid, whether engaged in any bafis, or difengaged, produces in the folution of filver by nitrous acid the fame effect as the vitriolic acid. It feparates from the nitrous acid the metal, with which it unites and forms a new compound, or a *marine falt with bafis of filver*, known to chemifts by the name of *luna cornea*, or *corneous filver*. *See* LUNA CORNEA. It is called corneous, becaufe this filver, united with marine acid by expofure to fire, may be melted; and may be coagulated by cold into a femi-tranfparent, femi-flexible mafs, like horn.

Luna cornea, although in a saline state, is very little soluble by water. The precipitate which it forms is very apparent: it is composed of flocks, which adhere one to another, and form a kind of white curd, that floats in the liquor. By this appearance alone it may be distinguished from vitriol of silver.

These properties of a solution of silver, together with the facility with which it is rendered turbid by the presence of the smallest quantity of vitriolic and marine acids, disengaged or combined with any basis, render it very convenient and much used for the examination of waters, and in other chemical operations, to ascertain the presence of these two acids, in whatever compound they may be contained.

Silver, as well as all metals, may be separated from any acid by absorbent earths, or by fixed and volatile alkalis; and when afterwards fused, it recovers its original properties. Silver, thus dissolved, precipitated, and melted, is generally very pure. We may be certain that silver, which has been formed into luna cornea, and afterwards has been reduced, does not contain a particle of gold, platina, copper, iron, or other metallic substance soluble in aqua regia, and consequently not separable from nitrous acid by means of marine acid.

From what has been said concerning these several decompositions of a solution of silver made by nitrous acid, we may infer that this combination may be decomposed;

1. By the action of fire alone, which expels the nitrous acid.

2. By phlogiston, which burns and destroys nitrous acid in the detonation of lunar nitre.

3. By precipitation with saline or earthy alkalis, which seize the nitrous acid, and leave the silver disengaged in the state of a precipitate.

4. By vitriolic acid, which seizes the silver, and leaves the nitrous acid disengaged.

5. By marine acid, which has the same effect.

6. Lastly, several metals, and especially copper, having a stronger affinity than silver with nitrous acid, decompose also this solution of silver, by seizing the acid, and obliging the silver to separate from it, which it does by precipitating it in its proper metallic state. *See the words* PRECIPITATE *and* PRECIPITATION.

Sulphur dissolves silver by fusion, and forms with it a blackish mass, which may be cut, and which has almost the color and consistence of lead. It is called *sulphurated silver*.

ſilver. This compound is a kind of artificial ore of ſilver. Some expert perſons are ſaid to be able to imitate very well by this mixture ſome natural ores of ſilver.

To make this combination, ſilver and ſulphur are laid alternately upon each other in ſeveral ſtrata in a crucible, which is to be heated by degrees till the whole be fuſed. Leſs heat is required for this fuſion than if the ſilver was alone, becauſe ſulphur facilitates the fuſion of this, as well as of all other metals difficultly fuſible, upon which it is capable of acting.

The ſulphur may be ſeparated from the ſilver by the mere action of the fire, continued during a certain time with acceſs of air. When ſulphurated ſilver is detonated with nitre, this ſeparation is very well and inſtantly made. As this metal is indeſtructible by all theſe agents, it is found to be unchanged by theſe operations.

Juncker relates, after Kunckel, that if ſulphur be diſſipated from ſulphurated ſilver by the action of fire; and if a volatile alkaline ſpirit of urine be poured upon this ſilver, a blue color is produced. He adds alſo, that this does not happen a ſecond time to the ſame ſilver, unleſs it be firſt cupelled with lead. This chemiſt concludes from thence, that this color proceeds from copper which the ſilver receives from the lead. *See Conſpectus Chymiæ, Tom.* I. *p.* 893.

Silver is found within the earth in different ſtates. A very ſmall quantity of it is in its natural and malleable ſtate, allayed with copper and gold; and is then called *virgin* or *native ſilver:* but ſilver is generally found in a mineral ſtate, that is, united and incorporated with heterogeneous matters, ſuch as other metallic ſubſtances, and the mineraliſing ſubſtances, namely, ſulphur and arſenic. It is ſeparated from all theſe matters by particular proceſſes practiſed both in eſſays and in ſmelting the ore in large quantities. *See* ORES *of* SILVER.

Silver is purified from the allay of other deſtructible metals by treating it with nitre, or with lead. *See* PURIFICATION *of* SILVER *by* NITRE. The latter method is generally uſed by refiners, and is called *cupellation*, or *refining*. *See* REFINING.

All theſe operations are founded in general upon the deſtructibility of imperfect metals, and on the indeſtructibility of ſilver, which is a perfect metal: but as gold is an indeſtructible metal, all the purifications of ſilver, which are only effected by the deſtruction of metals allayed within it, are

ſufficient to ſeparate it from gold. We muſt therefore have recourſe to other operations, for the ſeparation of theſe two metals from each other. Theſe operations, which are called by the general name of *parting*, are founded upon the property which ſilver has of being ſoluble by many menſtrua which do not act upon gold. Theſe menſtrua are;

1. Nitrous acid, which diſſolves ſilver without touching gold. By means of this acid, ſilver is generally parted from gold, and the operation is called *parting*, without any epithet to diſtinguiſh it from the others. *See* PARTING.

2. Marine acid, which being applied conveniently to a mixture of gold and ſilver, ſeizes the latter metal excluſively of the former. As this parting is performed by cementation, and as the marine acid muſt be highly concentrated, it is called concentrated parting. *See* PARTING (CONCENTRATED).

3. Laſtly, ſulphur, which unites alſo to ſilver without touching gold, furniſhes a third method of ſeparating theſe two metals. This is called *dry parting*, becauſe it is made by fuſion, which chemiſts call the *dry way*. *See* PARTING (DRY).

Silver is capable of being allayed with all metals, and forms with them different compounds, the properties of which may be ſeen under the word ALLAY.

According to Mr. Geoffroy's Table of Affinities, thoſe of ſilver are firſt to lead, and then to copper; and Mr. Gellert's Table mentions only gold.

SIMILOR. This is a name given to an allay of red copper and zinc, made in the beſt proportions to imitate the color of gold. *See* COPPER, BRASS, *and* ZINC.

SMALT. It is a blue glaſs compoſed of the calx of cobalt, vitrified and melted with ſome fritt of glaſs or cryſtal. Ground ſmalt is called *azure*, or *enamel blue*. *See* AZURE, COBALT, *and* ZAFFRE.

SMELTING *of* ORES. We have ſhewn, under the articles ORES and PYRITES, the nature of the principal metallic minerals, and the ſubſtances of which they are compoſed. We have alſo explained, under the article ESSAY OF ORES, the proceſſes by which an exact analyſis of theſe compound minerals may be made, and the nature and quantity of the contained metals may be known. In order to complete what relates to this important ſubject, we ſhall deſcribe in this article the principal operations by which are obtained "in the great," as it is called, or for commercial purpoſes, metals, ſulphur, vitriols, and other uſeful

ful substances contained in metallic minerals. What we shall say upon this subject will chiefly be extracted from a *Treatise on the Smelting of Ores, by Schlutter*, translated from the German into French by *M. Hellot*; because this, of all the modern works upon that subject, appears to be the most exact. We shall first describe the operations upon pyritous matters for the extraction of sulphur, vitriols, and alum; and afterwards the operations by which metallic substances are extracted from ores properly so called; from which also are occasionally obtained the same matters as from the pyrites. As the present article is only the sequel of the articles ORES, PYRITES, and ESSAYS *of* ORES, it is evident that these articles ought to be read previously to this.

EXTRACTION *of* SULPHUR *from* PYRITES *and other* MINERALS.

In order to obtain sulphur from pyrites, this mineral ought to be exposed to a heat sufficient to sublime the sulphur, or to make it distill in vessels, which must be close, to prevent its burning.

Sulphur is extracted from pyrites at a work at *Schwartzemberg*, in *Saxony*, in the high country of the mines; and in *Bohemia*, at a place called *Alten-Sattel*.

The furnaces employed for this operation are oblong, like vaulted galleries; and in the vaulted roofs are made several openings. These are called *furnaces for extracting sulphur*. *See* PLATE II. *Fig.* 9.

In these furnaces are placed earthen-ware tubes, filled with pyrites broken into pieces of the size of small nuts. Each of these tubes contains about fifty pounds of pyrites. They are placed in the furnace almost horizontally, and have scarcely more than an inch of descent. The ends, which come out of the furnace five or six inches, become gradually narrower. Within each tube is fixed a piece of baked earth, in form of a star, at the place where it begins to become narrower, in order to prevent the pyrites from falling out, or choaking the mouth of the tube. To each tube is fitted a receiver, covered with a leaden plate, pierced with a small hole to give air to the sulphur. The other end of the tube is exactly closed. A moderate fire is made with wood, and in eight hours the sulphur of the pyrites is found to have passed into the receivers.

The residuum of the pyrites, after the distillation, is drawn out at the large end, and fresh pyrites is put in its place.

place. From this residuum, which is called *burnings of sulphur*, vitriol is extracted; as we shall presently relate.

The eleven tubes into which were put, at three several distillations, in all nine quintals, or 900 pounds of pyrites, yield from 100 to 150 pounds of crude sulphur, which is so impure as to require to be purified by a second distillation.

This purification of crude sulphur is also done in a furnace in form of a gallery, in which five iron cucurbits are arranged on each side. These cucurbits are placed in a sloping direction, and contain about eight quintals and a half of crude sulphur. To them are luted earthen tubes, so disposed as to answer the purpose of capitals. The nose of each of these tubes is inserted into an earthen pot, called the *fore-runner*. This pot has three openings; namely, that which receives the nose of the tube; a second smaller hole, which is left open to give air; and a third in its lower part, which is stopped with a wooden peg. *See* PLATE II. *Fig.* 10.

When the preparations are made, a fire is lighted about seven o'clock in the evening, and is a little abated as soon as the sulphur begins to distill. At three o'clock in the morning, the wooden pegs, which stop the lower holes of the fore-runners, are for the first time drawn out, and the sulphur flows out of each of them into an earthen pot with two handles placed below for its reception. In this distillation the fire must be moderated and prudently conducted; otherwise less sulphur would be obtained, and it also would be of a grey color, and not of the fine yellow which it ought to have when pure. The ordinary loss in the purification of eight quintals of crude sulphur is, at most, one quintal.

When all the sulphur has flowed out, and has cooled a little in the earthen pots, it is cast into moulds made of beech tree, which have been previously dipt in water, and set to drain. As soon as the sulphur is cooled in the moulds, they are opened, and the cylinders of sulphur are taken out and put up in casks. These are called *roll-brimstone*.

As sulphur is not only in pyrites, but also in most metallic minerals, it is evident that it might be obtained by works in the great from the different ores which contain much of it, and from which it must be separated previously to their fusion: but as sulphur is of little value, the trouble

ble of collecting it from ores is seldom taken. Smelters are generally satisfied with freeing their ores from it, by exposing them to a fire sufficient to expel it. This operation is called *torrefaction*, or *roasting of ores*.

There are, however, ores which contain so much sulphur, that part of it is actually collected in the ordinary operation of roasting, without much trouble for that purpose. Such is the ore of *Ramelsberg*, in the country of *Hartz*.

This ore, which is of lead, containing silver, is partly very pure, and partly mixed with cupreous pyrites and sulphur; hence it is necessary to roast it.

The roasting is performed by laying alternate strata of ore and wood upon each other in an open field, taking care to diminish the size of the strata as they rise higher; so that the whole mass shall be a quadrangular pyramid truncated above, whose base is about thirty-one feet square. Below, some passages are left open, to give free entrance to the air; and the sides and top of the pyramid are covered over with small ore, to concentrate the heat and make it last longer. In the center of this pyramid there is a channel, which descends vertically from the top to the base. When all is properly arranged, ladle-fulls of red-hot scoria from the smelting furnace are thrown down the channel, by which means the shrubs and wood, placed below for that purpose, are kindled, and the fire is from them communicated to all the wood of the pile, which continues burning till the third day. At that time the sulphur of the mineral becomes capable of burning spontaneously, and of continuing the fire after the wood is consumed.

When this roasting has been continued fifteen days, the mineral becomes greasy, that is, it is covered over with a kind of varnish: twenty or twenty-five holes, or hollows, are then made in the upper part of the pile, in which the sulphur is collected. From these cavities the sulphur is taken out thrice every day, and thrown into water. This sulphur is not pure, but crude, and is therefore sent to the manufacturers of sulphur to be purified in the manner above related. *See* PLATE II. *Fig.* 11. *and* 12.

As this ore of Ramelsberg is very sulphureous, the first roasting, which we are now describing, lasts three months; and during this time, if much rain has not fallen, or if the operation has not failed by the pile falling down or cracking, by which the air has so much free access, that the sulphur

ſulphur is burnt and conſumed, from ten to twenty quintals of crude ſulphur are by this method collected.

The ſulphur of this ore, like that of moſt others, was formerly neglected, till, in the year 1570, a perſon employed in the mines, called Chriſtopher Sauder, diſcovered the method of collecting it, nearly as it is done at preſent.

Metallic minerals are not the only ſubſtances from which ſulphur is extracted. This matter is diffuſed in the earth in ſuch quantities, that the metals cannot abſorb it all. Some ſulphur is found quite pure, and in different forms, principally in the neighbourhood of volcanos, in caverns, and in mineral waters. Such are the opake kind called *virgin ſulphur*, the tranſparent kind called *ſulphur of Quito*, and the native flowers of ſulphur, as thoſe of the waters of Aix-la-Chapelle. It is alſo found mixed with different earths. Here we may obſerve, that all thoſe kinds of ſulphur which are not mineraliſed by metallic ſubſtances, are found near volcanos, or hot mineral waters, and conſequently in places where nature ſeems to have formed great ſubterranean laboratories, in which ſulphureous minerals may be analyſed and decompoſed, and the ſulphur ſeparated, in the manner in which it is done in ſmall in our works and laboratories. However that be, certainly one of the beſt and moſt famous ſulphur mines in the world is that called *Solfatara*. The Abbé Nollet has publiſhed, in the Memoirs of the Academy, ſome intereſting obſervations upon this ſubject, which we ſhall here abridge.

Near Puzzoli, in Italy, is that great and famous mine of ſulphur and alum called at preſent *Solfatara*. It is a ſmall oval plain, the greateſt diameter of which is about 400 yards, raiſed about 300 yards above the level of the ſea. It is ſurrounded by high hills and great rocks, which fall to pieces, and whoſe fragments form very ſteep banks. Almoſt all the ground is bare and white, like marle, and is every where ſenſibly warmer than the atmoſphere in the greateſt heat of ſummer; ſo that the feet of perſons walking there are burnt through their ſhoes. It is impoſſible not to obſerve the ſulphur there; for every where may be perceived by the ſmell a ſulphureous vapor, which riſes to a conſiderable height, and gives reaſon to believe that there is a ſubterraneous fire below, from which that vapor proceeds.

Near

Near the middle of this field there is a kind of bason three or four feet lower than the rest of the plain, in which a sound may be perceived when a person walks on it, as if there were under his feet some great cavity, the roof of which was very thin. After that, the lake Agnano is perceived, whose waters seem to boil. These waters are indeed hot, but not so hot as boiling water. This kind of ebullition proceeds from vapors which rise from the bottom of the lake, which being set in motion by the action of subterranean fires, have force enough to raise all that mass of water. Near this lake there are pits, not very deep, from which sulphureous vapors are exhaled. Persons who have the itch, come to these pits, and receive the vapors in order to be cured. Finally, there are some deeper excavations, whence a soft stone is procured which yields sulphur. From these cavities vapors exhale, and issue out with noise, and which are nothing else than sulphur subliming through the crevices. This sulphur adheres to the sides of the rocks, where it forms enormous masses: in calm weather the vapors may be evidently seen to rise 25 or 30 feet from the surface of the earth.

These vapors, attaching themselves to the sides of rocks, form enormous groups of sulphur, which sometimes fall down by their own weight, and render these places of dangerous access.

In entering the Solfatara, there are warehouses and buildings erected for the refining of sulphur.

Under a great shed, or hangar, supported by a wall behind, open on the other three sides, the sulphur is procured by distillation from the soft stones we mentioned above. These stones are dug from under ground; and those which lie on the surface of the earth are neglected. These last are, however, covered with a sulphur ready formed, and of a yellow color: but the workmen say they have lost their *strength*, and that the sulphur obtained from them is not of so good a quality as the sulphur obtained from the stones which are dug out of the ground.

These last mentioned stones are broken in lumps, and put into pots of earthen ware, containing each about twenty pints, Paris measure. The mouths of these pots are as wide as their bottoms; but their bellies, or middle parts, are wider. They are covered with a lid of the same earth, well luted, and are arranged in two parallel lines along two brick walls, which form the two sides of a furnace. The pots are placed within these walls; so that the center

of

of each pot is in the center of the thickness of the wall and that one end of the pots overhangs the wall within, while the other end overhangs the wall without. In each furnace ten of these pots are placed; that is, five in each of the two walls which form the two sides of the furnace. Betwixt these walls there is a space of fifteen or eighteen inches; which space is covered by a vault resting on the two walls. The whole forms a furnace seven feet long, two feet and a half high, open at one end, and shut at the other, excepting a small chimney, through which the smoke passes.

Each of these pots has a mouth in its upper part without the furnace, in order to admit a tube of eighteen lines in diameter and a foot in length, which communicates with another pot of the same size placed without the building, and pierced with a round hole in its base of fifteen or eighteen lines diameter. Lastly, to each of these last mentioned pots there is a wooden tub placed below, in a bench made for that purpose.

Four or five of these furnaces are built under one hangar or shed. Fires are kindled in each of them at the same time; and they are thrown down after each distillation, either that the pots may be renewed, or that the residuums may be more easily taken out.

The fire being kindled in the furnace, heats the first pots containing the sulphureous stones. The sulphur rises in fumes into the upper part of the pot, whence it passes through the pipe of communication into the external vessel. There the vapors are condensed, become liquid, and flow through the hole below into the tub, from which the sulphur is easily turned out, because the form of the vessel is that of a truncated cone, whose narrower end is placed below, and because the hoops of the tub are so fastened that they may be occasionally loosened. The mass of sulphur is then carried to the buildings mentioned before, where it is remelted for its purification, and cast into rolls, such as we receive it.

EXTRACTION *of* VITRIOL *from* PYRITES.

Sulphur is not the only substance procured from pyrites; for besides that, different kinds of vitriols and alum, according to the nature of pyrites, are also extracted: so that pyrites may be considered as the ores of vitriols and alum as well as of sulphur.

These

These salts do not exist in the pyrites ready formed, as the sulphur does; but are, on the contrary, the products of the decomposition of pyrites, and are new combinations resulting from this decomposition. In the pale-yellow martial pyrites, this decomposition is effected without any other means than by exposure to moisture and air, and by the re-action of the sulphureous principle upon the iron which the pyrites contains, and with which the acid of the sulphur forms martial vitriol, as we may see under the article PYRITES. When the vitriol of this pyrites is to be extracted, this mineral is to be laid in a large heap three feet thick, and exposed to the air during three years, till it has entirely fallen into powder; and it is then to be stirred up every six months to accelerate the efflorescence. The rain-water, which has washed it, is to be conducted into caldrons, into which old iron is thrown to saturate the superfluous acid. After this succeeds the evaporation and crystallization.

It is not necessary that the pyrites should fall into efflorescence for the extraction of vitriol. The action of the fire which decomposes one part of the sulphur produces the same effect. Thus, in the works at Schwartzemberg in Upper Saxony, the vitriol is extracted, by lixiviating the pyrites after the distillation of the sulphur, which is called in some works, as we have before said, the *burnings of sulphur*, and which are in this work called *sulphur-brands*. This operation consists in impregnating well the lixivium with vitriol, by pouring it upon fresh parcels of these sulphur-brands, which is called doubling the lixivium: then it is evaporated in a leaden caldron, called the *sulphur-caldron*; and afterwards it is crystallized in a wooden vessel. The sulphur-brands, from which vitriol has been extracted, are not thereby exhausted; but they are exposed to the open air for two years, and are then again lixiviated for the extraction of more vitriol.

Vitriol is also made at *Geyer*, in Upper Saxony. The difference betwixt the method employed there and at Schwartzemberg, is, that at Geyer the pyrites has not been used for the extraction of sulphur by distillation, but has been roasted fifteen days, and afterwards lixiviated. The lixivium is evaporated in leaden caldrons, and afterwards put in shallow tubs called coolers, where it deposites a yellow mud. The evaporation and depuration of this lixivium lasts twenty-four hours, and then the liquor is put into tubs to crystallize.

The

The pyrites, which has been roasted and lixiviated once at Geyer, is not thereby exhausted; but is made to undergo the same operation four or five times, by which it furnishes more vitriol. The yellow mud which is deposited from the lixivium is sold, as a coloring material, to painters, after it has been calcined to redness.

Nature furnishes a vitriol ready formed in some mineral earths, to obtain which vitriol, nothing but lixiviation is necessary. Such is that vitriol obtained at Cremnitz, where there is a rich ore of gold. The vitriol is there extracted merely for the purpose of preparing aqua-fortis, which is necessary in the operation for parting the gold contained in that ore. In the neighbourhood of Cremnitz, a soft rock and clay are found, containing vitriol, and which furnish it by means of lixiviation.

To this kind of vitriol ready formed may be referred that obtained at Goslar by the lixiviation of a mineral earth, composed of particles of different ores, found in the galleries of the mine at Ramelsberg, of which we have already spoken. The workmen call this substance the *smoke of copper*. It requires lixiviation only to furnish vitriol. It is true, that by the wood-fires made in these galleries to calcine the rocks, the metallic matters may be disengaged, and a part of the sulphur burnt, the acid of which, mixing with the subterranean waters, dissolves all the metallic matters it meets, and forms all kinds of vitriols. Nevertheless, some of these vitriolic waters, and even some crystallized vitriols, are found in these galleries, where no fire is ever made. The Germans call all these vitriols by the general name *Joekels*. Some vitriols are also found not crystallized, but forming various colored stones, which furnish vitriol by lixiviation. They are called *ink-stones*. What is called *misy* is a yellow, shining, vitriolic stone or earth, found in the same places.

To return to the substance called smoke of copper, whence the martial vitriol is extracted at Goslar; several lixiviums are made of it, by pouring the same water upon different parcels of it: it is then made to evaporate, to deposite its sediment, and to crystallize, as we have already said. The first water is called the *wild ley*. The several vessels employed at Goslar are named from their several uses, as the *washing tub*, *mud tub*, &c.

This substance remaining after the lixiviation of this smoke of copper, is a kind of ore not entirely deprived of metallic substances. The workmen call the finest part of it

small

ſmall vitriol, and the larger pieces they call *ſtones*, or *kernels of vitriol*. Both theſe are carried to the ſmelting houſes to be roaſted and melted with the Rammelſberg ore, that the lead and ſilver, which they contain, as well as that ore, may be extracted.

A white vitriol, whoſe baſis is zinc, is alſo procured at Goſlar from the ſame Rammelſberg ore. This vitriol was diſcovered in the year 1570 by the Duke Julian, who called it *alum of the mine*. At preſent it is known by the names, *white vitriol*, *vitriol of zinc*, *Goſlar vitriol*.

To make this vitriol, the ore of Rammelſberg, containing lead and ſilver, having been previouſly roaſted for the obtaining of ſulphur, as we have already deſcribed, undergoes the ſame operations which are practiſed for the preparation of martial vitriol, excepting the formation of large cryſtals, which is here purpoſely prevented, by liquefying the vitriol after it is formed in copper caldrons. This liquefaction is effected by means of the water retained in the cryſtallization of the vitriol. While the vitriol is liquefied, a part of the moiſture is evaporated, and women employed in this work keep ſtirring it till it has acquired the requiſite conſiſtence. By this ſtirring, it is divided into very fine cryſtalline particles, and it acquires the whiteneſs of the fineſt ſugar; a quality which makes it ſaleable, and which is procured by the means above related, and by carefully making it depoſite the ferruginous matter with which theſe lixiviums are always impregnated.

As to the blue vitriol, or vitriol of copper, it is extracted from the cupreous pyrites, or even from ſulphureous copper ores, by the operations already mentioned. Frequently the ferruginous pyrites and minerals alſo contain copper: and therefore the vitriol extracted from them is half martial and half cupreous, and is of a ſea-green color.

EXTRACTION *of* ALUM *from* PYRITOUS SUBSTANCES *and from* ALUMINOUS EARTHS.

One part of the unmetallic earth which is always in pyrites, and in other metallic and ſulphureous minerals, is ſometimes of that kind of earths which are ſoluble in acids, and particularly of the nature of that earth which is the baſis of alum.

When the pyrites contains ſome of this kind of earth, the acid of its ſulphur being diſengaged either by the efflo-

refcence of the pyrites, or by its calcination and combuftion, ought to unite itfelf as readily, and even more fo, to this earth than to the metals contained in the fame pyrites, and form a true alum: accordingly fo it happens, and alum is extracted from pyrites or other fulphureous minerals containing this earth, by proceffes fimilar to thofe employed for the extraction of vitriols.

In England, a pyritous, flate-colored, fulphureous ftone is found, from which alum is extracted by torrefaction and lixiviation; but to this lixivium a certain quantity of foffile alkali, diffolved in water, is generally added.

The Swedes have a fhining pyrites of a golden color, and fpeckled with filvery fpots, from which they extract fulphur, vitriol, and alum. Sulphur and vitriol are extracted from it by the methods we have defcribed; and when the lixivium yields no more cryftals of vitriol, an eighth part of putrefied urine and lixivium of wood-afhes is added, by which a martial earth is precipitated: the liquor being poured off, cryftals of alum are obtained by evaporation.

Finally, it appears that in general, when alum is to be extracted from fulphureous and metallic minerals, fine and pure cryftals cannot be without fome difficulty obtained. It is almoft always neceffary to have recourfe to fome additions of alkaline matters, fuch as quicklime, and fixed or volatile alkaline falts.

Thefe difficulties proceed partly from this, that different kinds of falts are formed at the fame time by the decompofition of thefe minerals; and that thefe falts are cryftallized by nearly the fame degrees of evaporation and cold: hence a confufion of falts muft neceffarily follow: and hence we do not find many of the vitriols, extracted from fuch minerals, perfectly pure and free from alum, or from vitriolic falts with earthy bafes fimilar to alum. The *falt of colcothar* and the *gilla vitrioli* are nothing elfe than thefe foreign falts. On the other hand, the alum which is extracted from metallic minerals contains almoft always fome vitriol, and particularly martial vitriol. *(l)*

But there are unmetallic earths and ftones which contain alum, or its materials, ready formed. Such is that earth

(l) From Mr. Margraaf's experiments, an addition of fome alkaline fubftance feems to be always neceffary to the formation of large cryftals of alum, however free the lixivium is from the mixture of vitriols or other falts. *See a note fubjoined to the article* ALUM (ROMAN).

whence

whence alum is extracted at Solfatara. This mineral is an earth similar to marle in consistence and color. It is gathered in the plain, and in the western part of the Solfatara. It is put into leaden caldrons two feet and a half in diameter, and as much in depth, till these vessels be three quarters full. The caldrons are sunk so as to be almost level with the ground, under a great hangar or shed, at a distance of four hundred paces from the sulphur furnaces. Into each caldron water is poured till it rise three or four inches above the mineral. The heat of the ground in this place is sufficient to warm the matter, as it makes Mr. Reaumur's thermometer rise to $37\frac{1}{2}$ degrees above the freezing point. By this means, without the expence of wood, the saline part is separated from the earthy, and is obtained in large crystals.

Alum in this state is still mixed with many impurities, and is carried to the building at the entry of the Solfatara, where it is dissolved by hot water in a great stone vessel in form of a funnel. The purification of alum may be made so much more advantageously in this place, as no wood is necessary, the natural heat of the place being sufficient for the process.

To this kind of natural alum may be referred that which is obtained merely by evaporation from some mineral waters; and also the Roman alum which is obtained from a kind of free-stone, although a calcination during twelve or fourteen hours, and an exposition to the air till it falls into efflorescence be necessary. This stone is not pyritous, but rather of the marle kind: therefore its efflorescence is probably nothing more than an extinction, and differs essentially from the efflorescence of pyrites.

Such are the processes by which sulphur, vitriol, and alum are obtained from minerals containing these substances.

These minerals contain a great quantity of vitriolic acid, which chemists can separate from them; and they are, as it were, the grand magazines where nature deposites this acid, which is always found combined, as we have seen, with some substance or basis.

SMELTING *of* ORES *in general.*

As ores consist of metallic matters combined with sulphur and arsenic, and are besides intermixed with earthy and stony substances of all kinds, the intention of all the operations upon these compound bodies is to separate these

 different

different ſubſtances from each other. This is effected by ſeveral operations founded on the known properties of thoſe ſubſtances. We now proceed to give a general idea of theſe ſeveral operations.

Firſt of all, the ore is to be ſeparated from the earths and ſtones accidentally adherent to it; and when theſe foreign ſubſtances are in large maſſes, and are not very intimately mixed in ſmall particles with the ore, this ſeparation may be accompliſhed by mechanical means. This ought always to be the firſt operation, unleſs the adherent ſubſtance be capable of ſerving as a flux to the ore. If the unmetallic earths be intimately mixed with the ore, this muſt neceſſarily be broken and divided into ſmall particles. This operation is performed by a machine which moves peſtles, called bocards, or ſtampers. After this operation, when the parts of the mineral are ſpecifically heavier than thoſe of the unmetallic earth or ſtone, theſe latter may be ſeparated from the ore by waſhing in canals through which water flows. With regard to this waſhing of ores, it is neceſſary to obſerve, that it cannot ſucceed but when the ore is ſenſibly heavier than the foreign matters. But the contrary happens frequently, as well becauſe quartz and ſpar are naturally very ponderous, as becauſe the metallic matter is proportionably ſo much lighter as it is combined with more ſulphur.

When an ore happens to be of this kind, it is neceſſary to begin by roaſting it, in order to deprive it of the greateſt part of its ſulphur.

It happens frequently that the pyritous matters accompanying the ore are ſo hard that they can ſcarcely be pounded. In this caſe it is neceſſary to roaſt it entirely, or partly, and to throw it red-hot into cold water; by which the ſtones are ſplit, and rendered much more capable of being pulveriſed.

Thus it happens very frequently, that roaſting is the firſt operation to which an ore is expoſed.

When the ſubſtance of the ore is very fuſible, this firſt operation may be diſpenſed with, and the matter may be immediately fuſed, without any previous roaſting, or at leaſt with a very ſlight one. For, to effect this fuſion, it is neceſſary that it retain a great quantity of its ſulphur, which, with the other fluxes added, ſerves to deſtroy or convert into ſcoria a conſiderable part of the ſtony matter of the mineral, and to reduce the reſt into a brittle ſubſtance, which is called the *matt of lead*, or of *copper*, or other metal contained in the ore. This matt is therefore

an

...ral and the metal; ...d mixed with less . But as this matt is ...ch it contains cannot ...refore it must be roasted ...ur, before it is remelted, . This fusion of an ore not . is called *crude fusion*.

...n the subject of washing and ...ic is heavier than sulphur, and metals, the ores in which it ...y heavy, and consequently are ...d, which is a great advantage. ...as arsenic is capable of volatilising, ...ing many metals, these ores have ... roasting and fusion, in both which caused by the arsenic. Some ores con-...c, other volatile semi-metals, such as an-. These are almost untractable, and are ...ed. They are called *mineræ rapaces*, rapa-

... metal has been freed as much as is possible ... matters by these preliminary operations, it ...compleatly purified by fusions more or less fre-...repeated; in which proper additions are made, ... absorb the rest of the sulphur and arsenic, or to ...t the vitrification or scorification of the unmetallic ...and earth.

...ly, as ores frequently contain several different metals, ... are to be separated from each other by processes suited ...the properties of these metals, of which we shall speak ...ore particularly as we proceed in our examination of the ...res of each metal. (m)

OPERA-

(m) To facilitate the extraction of metallic substances from the ores and minerals containing them, some operations previous to the fusion or smelting of these ores and minerals are generally necessary. These operations consist of, 1. The *separation* of the ores and metallic matters from the adhering unmetallic earths and stones, by hammers, and other mechanical instruments; and by washing with water. 2. Their *division* or reduction into smaller parts by contusion and trituration, that by another washing with water they may be more perfectly cleansed from extraneous matters, and rendered fitter for the subsequent operations, calcination or roasting, and fusion. 3. *Roasting* or *calcination*, the

SMELTING

OPERATIONS *on* ORES *of* NATIVE GOLD *and* SILVER, *by* WASHING *and by* MERCURY.

Earths and ſand are at firſt ſeparated by waſhing with water, by which operation the greateſt part of what is not gold,

the uſes of which operation are, to expel the volatile, uſeleſs, or noxious ſubſtances, as water, vitriolic acid, ſulphur, and arſenic; to render the ore more friable and fitter for the ſubſequent contuſion and fuſion; and, laſtly, to calcine and deſtroy the viler metals; for inſtance, the iron of copper-ores, by means of the fire, and of the ſulphur and arſenic. Stones, as quartz, and flints, containing metallic veins or particles, are frequently made red-hot, and then extinguiſhed in cold water, that they may be rendered ſufficiently friable and pulverable, to allow the ſeparation of the metallic particles.

Roaſting is unneceſſary for native metals; for ſome of the richer gold and ſilver ores; for ſome lead-ores, the ſulphur of which may be ſeparated during the fuſion; and for many calciform ores, as theſe do not generally contain any ſulphur and arſenic.

In the roaſting of ores, the following attentions muſt be given, 1. To reduce the mineral previouſly into ſmall lumps, that the ſurface may be encreaſed; but they muſt not be ſo ſmall, nor placed ſo compactly, as to prevent the paſſage of the air and flame. 2. The larger pieces muſt be placed at the bottom of the pile, where the greateſt heat is. 3. The heat muſt be gradually applied, that the ſulphur may not be melted, which would greatly retard its expulſion; and that the ſpars, fluors, and ſtones, intermixed with the ore, may not crack, fly and be diſperſed. 4. The ores not thoroughly roaſted by one operation muſt be expoſed to a ſecond. 5. The fire may be encreaſed towards the end, that the noxious matters more ſtrongly adhering may be expelled. 6. Fuel which yields much flame, as wood and foſſil coals free from ſulphur, is ſaid to be preferable to charcoal or coaks. Sometimes cold water is thrown on the calcined ore at the end of the operation, while the ore is yet hot, to render it more friable.

No general rule can be given concerning the duration or degree of the fire, theſe being very various according to the difference of the ores. A roaſting during a few hours or days is ſufficient for many ores; while ſome, ſuch as the ore of Rammelſberg, require that it ſhould be continued during ſeveral months.

Schlutter enumerates five methods of roaſting ores. 1. By conſtructing a pile of ores and fuel placed in alternate ſtrata, in the open air, without any furnace. *See* PLATE II. *Fig.* 11. *and Fig.*

gold, being lighter, is carried off. After this a second washing is made with mercury, which having the property of

Fig. 12. 2. By confining such a pile within walls, but without a roof. 3. By placing the pile under a roof, without lateral walls. 4. By placing the pile in a furnace consisting of walls and a roof. 5. By roasting the ore in a reverberatory furnace, in which it must be continually stirred with an iron-rod.

Several kinds of *fusions of ores* may be distinguished. 1. When a sulphureous ore is mixed with much earthy matter, from which it cannot be easily separated, by mechanical operations, it is frequently melted, in order to disengage it from these earthy matters, and to concentrate its metallic contents. By this fusion, some of the sulphur is dissipated, and the ore is reduced to a state intermediate betwixt that of ore and of metal. It is then called a *matt* (*lapis sulphureo-metallicus*), and is to be afterwards treated like a pure ore by the second kind of fusion, which is properly the *smelting*, or *extraction of the metal by fusion*. 2. By this fusion or smelting, the metal is extracted from the ore previously prepared by the above operations, if these be necessary. The ores of some very fusible metals, as of bismuth, may be smelted by applying a heat sufficient only to melt the metals, which are thereby separated from the adhering extraneous matters. This separation of metals by fusion, without the vitrification of extraneous matters, may be called *eliquation*. Generally, a compleat fusion of the ore and vitrification of the earthy matters are necessary for the perfect separation of the contained metals. By this method, metals are obtained from their ores, sometimes pure, and sometimes mixed with other metallic substances, from which they must be afterwards separated; as we shall see, when we treat of the extraction of particular metals. To procure this separation of metals from ores, these must be so thinly liquefied, that the small metallic particles may disengage themselves from the scoria; but it must not be be so thin as to allow the metal to precipitate before it be perfectly disengaged from any adhering extraneous matter, or to pervade and destroy the containing vessels and furnace. Some ores are sufficiently fusible; but others require certain additions called *fluxes*, to promote their fusion, and the vitrification of their unmetallic parts; and also to render the scoria sufficiently thin to allow the separation of the metallic particles.

Different fluxes are suitable to different ores, according to the quality of the ore, and of the matrix, or stone adherent to it.

The matrixes of two different ores of the same metal frequently serve as fluxes to each other; as, for instance, an argillaceous matrix with one that is calcareous; these two earths being disposed to vitrification when mixed, though each of them is singly unfusible. For this reason, two or more different ores to be smelted are frequently mixed together.

of uniting with gold, ſeizes this metal, amalgamates with it, and ſeparates it exactly from the earthy matters, with all which it can form no union.

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The ores alſo of different metals require different fluxes. Thus calcareous earth is found to be beſt ſuited to irón-ores, and ſpars and ſcoria to fuſible ores of copper.

The fluxes moſt frequently employed in the ſmelting of ores are calcareous earth, fluors or vitreous ſpars, quartz and ſand, fuſible ſtones, as ſlates, baſaltes, the ſeveral kinds of ſcoria, and pyrites.

Calcareous earth is uſed to facilitate the fuſion of ores of iron, and of ſome of the poorer ores of copper, and, in general, of ores mixed with argillaceous earths, or with feltſpar. This earth has been ſometimes added with a view of ſeparating the ſulphur, to which it very readily unites: but by this union, the ſulphur is detained, and a hepar is formed, which readily diſſolves iron and other metals, and ſo firmly adheres to them, that they cannot be ſeparated without more difficulty than they could from the original ore. This addition is therefore not to be made till the ſulphur be previouſly well expelled.

Fluors or *fuſible ſpars* facilitate the fuſion of moſt metallic minerals, and alſo of calcareous and argillaceous earths, of ſteatites, aſbeſtus, and of ſome other unfuſible ſtones, but not of ſiliceous earths without a mixture of calcareous earth.

Quartz is ſometimes added in the fuſion of ferruginous copper ores, the uſe of which is ſaid chiefly to be, to enable the ore to receive a greater heat, and to give a more perfect vitrification to the ferruginous ſcoria.

The *fuſible ſtones*, or *ſlates*, *baſaltes*, are ſo tenacious and thick when fuſed, that they cannot be conſidered properly as fluxes, but as matters added to leſſen the too great liquidity of ſome very fuſible minerals.

The *ſcoria* obtained in the fuſion of an ore is frequently uſeful to facilitate the fuſion of an ore of the ſame metal, and ſometimes even of ores of other metals.

Sulphurated pyrites greatly promote the fuſibility of the ſcoria of metals, from the ſulphur it contains. It is chiefly added to difficultly fuſible copper ores, to form the ſulphureous compounds called *matts*, that the ores thus brought into fuſion may be ſeparated from the adhering earthy matters, and that the ferruginous matter contained in them may be deſtroyed, during the ſubſequent calcination and fuſion, by means of the ſulphur.

As in the ores called *calciform*, the metallic matter exiſts in a calcined ſtate; and as calcination reduces the metals of mineraliſed ores (excepting the perfect metals) to that ſtate alſo; therefore all calciform and calcined ores require the addition of ſome

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The mercury thus charged with gold is preſſed through ſhamoy leather, and the gold is retained united with a part of the mercury, from which it may be eaſily diſengaged by expoſure to a proper degree of heat, which diſſipates and evaporates the mercury, while the gold, being fixed, remains.

This is the foundation of all the operations by which gold is obtained from the rich mines of Peru belonging to the Spaniards. Theſe operations conſiſt in waſhings, triturations, and amalgams in the great, by help of machines. We ſhall not enter into theſe details, becauſe they rather belong to mechanics than to chemiſtry. They who are deſirous to know them, may conſult a work written by Alonzo Barba on this ſubject.

The ores of native ſilver are much rarer and leſs abundant than thoſe of gold. But if any of this kind were found ſufficiently rich, they might be treated with mercury exactly in the ſame manner as the ores of native gold. *(n)*

SMELT-

inflammable ſubſtance to reduce them to a metallic ſtate. In great works, the charcoal or other fuel uſed to maintain the fire produces alſo this effect.

Metals are ſometimes added in the fuſion of ores of other more valuable metals, to abſorb from theſe ſulphur or arſenic. Thus iron is added to ſulphurated cupreous and ſilver ores. Metals are alſo added in the fuſion of ores of other more valuable metals, to unite with and collect the ſmall particles of theſe diſperſed through much earthy matter, and thus to aſſiſt their precipitation. With theſe intentions, lead is frequently added to ores and minerals containing gold, ſilver, or copper.

Ores of metals are alſo ſometimes added to aſſiſt the precipitation of more valuable metals. Thus antimony is frequently added to aſſiſt the precipitation of gold intermixed with other metallic matters. *See purification of gold by antimony.* Thus far of ſmelting of ores in general.

(n) Gold is frequently contained in the ores of other metals, either in a native or mineraliſed ſtate, and in ſands, eſpecially thoſe which are black and ferruginous. *See* ORES *of* GOLD.

If *gold be contained in ores of other metals*, theſe metals together with the gold may be firſt extracted by the ordinary proceſſes for ſmelting theſe ores; and the gold may be then ſeparated from the metallic maſs thus obtained, by mixing and fuſing this maſs with a quantity of lead, and by the proceſs of cupellation, deſcribed in the articles ESSAY *of the* VALUE *of* SILVER, *and* REFINING. Generally, the operations for obtaining gold from ores of imper-

fect

SMELTING

SMELTING *of* ORES *of* SILVER.

As ſilver, even in its proper ores, is always allayed with ſome other metals from which it is intended to be ſeparated, after that the ſilver ore has been well roaſted, it muſt be mixed with a greater or leſs quantity of lead previous to its fuſion.

Lead has the ſame effect in fuſion of gold and ſilver as mercury has upon theſe metals by its natural fluidity; that is to ſay, it unites with them, and ſeparates them from unmetallic matters, which, being lighter, riſe always to the ſurface. But lead has the further advantage of procuring, by its own vitrification, that of all metallic ſubſtances, excepting gold and ſilver. Hence it follows, that when gold and ſilver are obtained by means of mercury, they ſtill remain allayed with other metallic ſubſtances; whereas when they are obtained by fuſion and ſcorification with lead, they are then pure, and are not allayed with any metals, but with each other.

In proportion as the lead, which has been united to the gold and ſilver of the ore, is ſcorified by the action of the fire, and promotes the ſcorification of the other metallic matters,

fect metals are preciſely the ſame as thoſe for obtaining ſilver, to which therefore we refer. Moſt frequently a quantity of ſilver alſo is contained in theſe ores; and in this caſe the perfect metal obtained by cupellation is an allay of gold and ſilver, which muſt be afterwards ſeparated by the proceſſes called *parting*. *See* PARTING.

Many trials have been made to procure the ſmall quantity of gold contained in the *ferruginous ſands*, at a moderate expence (*See* ORES *of* GOLD); but as no work of this kind is now eſtabliſhed, we may preſume they have not been ſucceſsful. The beſt eſſays of this kind have been made, according to Schlutter, in the following manner.

The ſand is to be made red-hot, and extinguiſhed in cold water four times, by which its color is changed from the original yellow, red, or black, to a reddiſh brown. It is obſerved to emit, during the firſt and ſecond calcinations, an arſenical ſmell; and this ſmell may be produced again in the following calcinations by adding ſome inflammable matter. Let an ounce of the calcined ſand be mixed with two ounces of granulated lead, and one ounce of black flux, and put into a Heſſian crucible, with half an ounce of decrepitated ſea-ſalt upon the ſurface of the mixture. The crucible is to be placed in a good blaſt furnace, and a ſtrong

matters, it ſeparates the perfect metals, and carries with it all the others to the ſurface. There it meets the unmetallic ſubſtances, which it likewiſe vitrifies, and which it changes into a perfect ſcoria, fluid, and ſuch as a ſcoria ought to be to admit all the perfect metal contained in it to precipitate.

When all the heterogeneous matters have been thus diſengaged by ſcorification with lead, the perfect metals, to which ſome lead ſtill remains united, are to be further purified by the ordinary operation of the cupel.

The common rule for the fuſion and ſcorification of ſilver ore with lead, is to add to the ore a quantity of lead ſo much greater as there is more matter to be ſcorified, and as theſe matters are more refractory and of more difficult fuſion. Silver ores, or thoſe treated as ſuch, are often rendered refractory by ferruginous earths, pyritous matters, or cobalts, containing always a conſiderable quantity of an earth which is unmetallic, very ſubtle, and very refractory, and which renders a conſiderable augmentation of the quantity of lead neceſſary.

The quantity of lead which is commonly added to fuſible ſilver-ores, that do not contain lead, is eight times

ſtrong fire is to be excited. The matter contained in the crucible is to be frequently ſtirred with an iron-rod, and the heat is to be continued till the ſcoria is thin and perfectly fuſed. When the crucible is broken, a regulus of lead will be found, containing the gold and ſilver of the ſand. By this method Mr. Leberecht obtained, in eleven eſſays, from 840 to 844 grains of perfect metal from a quintal of ſand. Of the perfect metal obtained, from a fourth to a third part was gold. Some parcels of ſand have yielded more than a thouſand grains, and ſome not more than 350 grains per quintal. Inſtead of the granulated lead, and the black flux, which is too expenſive for great operations, ſome have added, to an ounce of the ſand, two ounces of litharge and a little powder of charcoal, by which they have obtained the ſame quantity of perfect metal. The ſcoria in theſe eſſays has been always found to contain ſome perfect metal.

The Hungarian copper ores, from which gold and ſilver are profitably extracted, contain a leſs quantity of theſe perfect metals than many ferruginous ſands. But they may be formed into a matt, by fuſion with pyrites, of which treatment the ſands are incapable. From this matt, the gold and ſilver, along with the copper of the ore, may be precipitated, and ſeparated from the ſulphur of the pyrites, by addition of iron, which being more diſpoſed than the other metals to unite with ſulphur, diſengages theſe metals, and allows them to precipitate.

the quantity of the ore. But when the ore is refractory, it is neceſſary to add twelve times the quantity of lead, and even more; alſo glaſs of lead, and fluxes, ſuch as the white and black fluxes; to which however borax and powder of charcoal are preferable, on account of the liver of ſulphur formed by theſe alkaline fluxes.

It is neceſſary to obſerve, that ſaline fluxes are only uſed in ſmall operations, on account of their dearneſs. To theſe are ſubſtituted, in the great operations, of which we now treat, ſandiver, fuſible ſcoria, and other matters of little value.

The greateſt part of the ſilver now employed in commerce is not obtained from the proper ores of ſilver, which are very ſcarce, but from lead, and even copper ores, which are more or leſs rich in ſilver. To give an idea of the manner of treating theſe kinds of ores, from which ſilver is extracted in the great works, we ſhall briefly deſcribe here, after Schlutter, the ſmelting of the ore of Rammelſberg, which contains, as we have already ſaid, ſeveral different kinds of metals, but particularly lead and ſilver.

When this mineral has been diſengaged from its ſulphur as much as poſſible, by three very long roaſtings, it is melted in the Lower Hartz in Saxony, in a particular kind of furnace, called a furnace for ſmelting upon a hollow or *caſſe*. *See* PLATE II. *Fig.* 13. The maſonry of this furnace is compoſed of large, thick ſlates, capable of ſuſtaining great heat, and cemented together by clay. The interior part of the furnace is three feet and a half long, and two feet broad at the back part, and one foot only the front. Its height is nine feet eight inches. It has a foundation of maſonry in the ground; and in this foundation channels are made for the evaporation of the moiſture. Theſe channels are covered over with ſtones called *covering ſtones*. The hollow or caſſe, which is made above theſe, is formed of bricks, upon which are placed, firſt, a bed of clay; then a bed of ſmall ore and ſifted vitriols; and, laſtly, a bed of charcoal-powder beat down, called *light braſque*. The anterior wall of the furnace is thinner than the others, and is called the *chemiſe*. The back wall, which is pierced to give paſſage to the pipes of two large wooden bellows, is called the middle wall. When the furnace is thus prepared, charcoal is thrown into the hollow, or caſſe; which being kindled, the fire is to be continued during three hours, before the matters to be fuſed are added. Then theſe matters are thrown in, which are not the

the pure ore, but a mixture of ſeveral ſubſtances, all of which are ſomewhat profitable. The quantity of theſe matters is ſufficient for one day's work; that is, for a fuſion of eighteen hours; and it conſiſts of, 1. Twelve ſchorbens or meaſures of well roaſted Rammelſberg ore; (the ſchorben is a meaſure whoſe contents are two feet five inches long, one foot ſeven inches broad, and a little more than a foot deep: It is equal to 32 quintals of that country, Cologn weight, at 123 pounds each quintal). 2. Six meaſures of ſcoria produced by the ſmelting of the ore of Upper Hartz, which is refractory, and what workmen called *cold*. 3. Two meaſures of *knobben*, which is an impure ſcoria containing ſome lead and ſilver, which has been formerly thrown away as uſeleſs, and is now collected by women and children. Beſides theſe, other matters are added, containing lead and ſilver, as the teſts employed in refining, the droſs of lead, impure litharge, and any rubbiſh containing metal, which was left in the furnace after the foregoing fuſion. All theſe matters being mixed together are thrown into the furnace: And to each meaſure of this mixture a meaſure of charcoal is added. The fuſion is then begun by help of bellows; and as it proceeds, the lead falls through the light braſque or charcoal bed, into the hollow, or caſſe, where it is preſerved from burning under the powder of charcoal. The ſcoria, on the other hand, being lighter and leſs fluid, is ſkimmed off from time to time by means of ladles, that it may not prevent the reſt of the lead from falling down into the hollow. Thus, while the fuſion laſts, freſh matters and freſh charcoal are alternately added, till the whole quantity intended for one fuſion, or, as they call it, one *day*, be thrown in.

There are ſeveral eſſential things to be remarked in this operation, which is very well contrived. Firſt, the mixture of matters from which a little lead and ſilver is procured, which would otherwiſe be loſt; and which have alſo this advantage, that they retard the fuſion of the Rammelſberg ore, which, however well roaſted it has been, retains always enough of the ſulphur and iron of the pyrites mixed with it, to render it too fuſible or too fluid, ſo that without the addition of thoſe matters, nothing would be obtained but a matt. It is even neceſſary, notwithſtanding theſe additions, not to haſten the fuſion too much, but to give time to the ore to mix with the other matters, elſe it would melt and flow of itſelf before the reſt. Secondly, the fuſion of the ore through charcoal, which is practiſed in

in most smelting-houses, and for almost all ores, is an excellent method, the principal advantage of which is the saving of fuel. The action of the burning charcoal directed immediately upon the mineral, at the same time that it melts more readily and efficaciously, also supplies it with the phlogiston necessary to bring it to a perfect state.

We mentioned, when treating of vitriols obtained from the Rammelsberg ore after its first roasting, that a *white vitriol* was also obtained, and prepared at *Goslar*, whose basis was *zinc*: which proves that this ore contains also a certain quantity of this semi-metal. As this ore is smelted in a country where the art is well understood of extracting every thing which a mineral contains, so in this fusion *zinc* and *cadmia* are obtained in the following manner. When the furnace is prepared for the fusion, it is necessary to close it up in the fore-part, before the fusion is begun.

" First of all, a gritt-stone is to be placed, supported at " the height of three inches. This stone is as long as the " furnace is broad, and the height of it is level with the " hole where the bellows-pipe enters. It is fastened on each " side of the furnace, externally and internally, with clay. " Upon this stone a kind of receptacle, or, as it is called, " the *seat of the zinc*, is made in the following manner. " A flat, slaty stone is chosen as long as the furnace " is broad, and eight inches in breadth. This is placed " on the gritt-stone above-mentioned, in such a manner, " that it inclines considerably towards the front of the fur- " nace, and that its bottom touches closely the gritt-stone. " It is fastened with clay, which is also laid upon the seat " of the zinc. Upon this seat, which is to receive the " zinc, are placed two round pieces of charcoal, and " also a stone called the *zinc-stone*, which is about a foot " and a half in length, and closes one part of the front " of the furnace. This stone also is fastened on each " of its sides with clay. Clay is likewise put under the " stone betwixt the two pieces of charcoal, which hinder it " from touching the seat of the zinc. The under part of " this stone is but slightly luted, that the workmen may " make an opening for the zinc to flow out. Thus is made " the seat or receptacle of the zinc to detain this metallic " substance, which would otherwise fall into the hottest " part of the fire, called by the workmen the melting-place, " and would be there burnt: whereas it is collected upon " this receptacle during the fusion, where it is sheltered

" from

" from the action of the bellows, and consequently from
" too great heat.

" When all the matter to be fused in one day is put into " the furnace, the blast of air is continued till that matter " has sunk down. When it is half way down the furnace, " they draw out the scoria, that more of the ore and other " matters may be exposed to the greatest heat. As soon as " the scoria is cooled and fixed a little, two shovel-fulls of " small wet scoria or sand is thrown close to the furnace, " and beat down with the shovel; then the workmen open " the seat or receptacle of zinc, and strike upon the zinc-" stone to make the semi-metal flow out. As soon as the " purest part of it has flowed out, it is sprinkled with " water and carried away. Then the workmen separate " intirely the zinc-stone from the wall of the furnace, " and they continue to give it little strokes, that the small " particles of zinc dispersed among the charcoal may fall " down. This being done, the stone is removed, and the " zinc is separated from the charcoal by an iron instru-" ment, is cleaned, and remelted along with the zinc that " flowed out at first, and is cast into round cakes. The " reason why the zinc is withdrawn before the bellows " cease to blow, is, that if it was left till the charcoal on " the seat or receptacle was consumed, it would be mostly " burnt, and little would be obtained. Thus, after the " zinc is withdrawn, the fusion is finished by blowing the " bellows till the end."

Thus the zinc is separated from the ore of Rammelsberg, and is not confounded in the hollow or casse with the lead and silver, because being a volatile semi-metal, it cannot support the activity of the fire without rising into vapors, which are condensed in the place least hot, that is to say, upon the stones expressly prepared for that purpose, and which being much thinner than the other walls of the furnace, are continually cooled by the external air.

It is also in this furnace, and after the fusion of the Rammelsberg ore, that the *cadmia of zinc*, or the *cadmia of furnaces*, is obtained. This ore is composed of sulphureous and ferruginous pyrites, of true lead ore containing silver, and a very hard and compact matter of a dark brownish-grey color, which is probably a lapis calaminaris, or an ore of zinc. These several matters of the Rammelsberg ore are not separated from each other, either for the roasting or for the fusion. Thus there is zinc in all the parts of the roasted ore, and much more of it would be obtained, if

if it was not so easily inflammable. All the zinc which is obtained is preserved from burning by falling, while in fusion, behind the chemise or forepart of the furnace, which is, as has been said, a kind of schistus, or slate, called by the workmen *steel stone*. But the part of this semi-metal which falls in the middle of the furnace, near the middle wall, or towards the sides, being exposed to the greatest heat of the fire, is there burnt; and its smoke or flowers attaching itself on all sides to the walls of the furnace, undergo there a semi-fusion, which renders this matter so hard and so thick that it must be taken away after every fourth fusion, or, at most, after every sixth fusion. That which is found attached to the highest part of the furnace is the best and purest. The rest is altered by a mixture of a portion of lead which it has carried up with it, and which, from its great weight and fixity, has hindered the zinc from rising so high as it would have done alone. Therefore with this kind of impure cadmia ductile brass cannot be made.

Almost all the zinc we have, as well as the cadmia of the furnaces, is obtained from the Rammelsberg ore, by the process described, and consequently is not the produce of a pure ore of zinc, or lapis calaminaris, which is never fused for that purpose. Before Mr. Margraaf, although it was well known that this ore contained zinc, and that it was employed for the making of brass, a convenient process for extracting zinc from it was not known, because when treated by fusion with fluxes, like other ores, it does not yield any zinc; which proceeds partly from the refractory quality of the earth contained in the calamine, that cannot be fused without a very violent fire; and also from the volatility and combustibility of the zinc, which for this reason cannot be collected at the bottom of a crucible, as a regulus under a scoria, like most metals.

M. Margraaf has remedied these inconveniences by distilling lapis calaminaris, mixed with charcoal, in a retort, to which is joined a receiver containing some water, and consequently in close vessels, where the zinc, by the help of a very strong fire indeed, is sublimed in its metallic form without burning. He also by the same method reduced into zinc the *flowers of zinc*, or *pompholix*, *cadmia of the furnaces*, *tutty*, which is also a kind of cadmia; in a word, all matters capable of producing zinc by combination with phlogiston. But it is evident that such operations as these are rather fit to supply proofs for chemical theory, than to be put in practice

practice for works in great. (n) M. Margraaf has observed, that the zinc which he obtained by this process was less brittle than what is obtained from the fusion of ores; which may proceed from its greater purity, or from its better combination with phlogiston.

After this digression which we have now made concerning the operation in the great, by which zinc and cadmia are obtained, and which we could not insert elsewhere, because of the necessary relation it has with the smelting of the Rammelsberg ore, we proceed to the other operations of the same ore, that is to say, to the *finery*, by which the silver is separated from the lead, which are mixed together, forming what is called the *work*.

This operation differs from the fining of essay, or in small, principally in this circumstance, that in the latter method of fining, all the litharge is absorbed into the cupel, whereas in the former method the greatest part of this litharge is withdrawn.

The fining in great of the work of Rammelsberg is performed in a furnace called a *reverberatory furnace*. This furnace is so constructed that the flame of wood burning in a cavity called the fire-place, is determined by a current of air, (which is introduced through the ash-hole, and which goes out at an opening on one side of that part of the furnace where the work is, that is, where the lead and silver are) to circulate above, and to give the convenient degree of heat, when the fire is properly managed. In this furnace a great cupel, called a *test*, is disposed. This test is made of the ashes of beech-wood, well lixiviated in the usual manner. In some founderies different matters are added, as sand, spar, calcined gypsum, quicklime, clay. When the test is well prepared and dried, all the work is put at once upon the cold test, to the quantity of sixty-four quintals for one operation. Then the fire is lighted in the fire-place with

(n) Zinc is obtained not only in the method used at Goslar above-described, but is also extracted in great works from lapis calaminaris and calcined blend, by a distillation similar to that by which Mr. Margraaf has essayed ores of zinc. The first work of that kind was erected in Sweden by Mr. Von Swab, in the year 1738. The ore employed was a kind of blend; this ore, when calcined, powdered, and mixed with charcoal, was put into iron or stone retorts, and the zinc was obtained by distillation. In Bristol a work is established in which zinc is obtained by distillation *by descent*. See a section and description of the furnace and apparatus employed, Plate II. *Fig.* 22, and *explanation*.

 faggots,

faggots, but the fusion is not urged too fast; 1. That the test may have time to dry; 2. Because the work of the Rammelsberg ore is allayed with the mixture of several metallic matters, which it is proper to separate from it, otherwise they would spoil the litharge and the lead procured from it. These metallic matters are, copper, iron, zinc, and matt. As these heterogeneous substances are hard and refractory, they do not melt so soon as the *work*, that is, as the lead and silver; and when the work is melted, they swim upon its surface like a skin, which is to be taken off. These impurities are called the *scum*, or the *first-waste*. What remains forms a second scum, which appears when the work is at its greatest degree of heat, but before the litharge begins to form itself. It is a scoria which is to be carefully taken off, and is called the *second-waste*.

When the operation is at this point, it is continued by the help of bellows, the wind of which is directed, not upon the wood or fuel, but upon the very surface of the metal, by means of iron plates put for that purpose before the blast hole, which are called *papillons*. This blast does not so much encrease the intensity of the fire, as it facilitates the combustion of the lead, and throws the litharge that is not imbibed by the test towards a channel, called the *litharge way*, through which it flows. The litharge becomes fixed out of the furnace; the matter which is found in the middle of the largest pieces, and which amounts to about a half or a third of the whole, is friable, and falls into powder like sand. This is put into barrels containing each five quintals of it, and is called saleable litharge, because it is sold in that state. The other part which remains solid is called *cold litharge*, and is again melted and reduced into lead. The fusion is called *cold fusion*, and the lead obtained from it, *cold lead*, which is good and saleable when the *work* has been well cleared from the heterogeneous matters mentioned above. The tests and cupels impregnated with litharge are added in the fusion of the ore, as we have already related.

When two-thirds, or nearly that quantity, of the lead are converted into litharge, no more of it is formed. The silver then appears covered with a white skin, which the finers call *lightening*, and the metal, *lightened* or *fined silver*.

The silver obtained by this process of fining is not yet altogether pure. It still contains some lead, frequently to the quantity of four drams in each marc, or eight ounces. It is delivered to the workmen, who complete its purification

purification by the ordinary method. This last operation is the *refining*, and the workmen employed to do it are called *refiners*. A fining of sixty-four quintals of *work*, yields from eight to ten marcs of fined silver, and from thirty-five to forty quintals of litharge; that is, from twelve to eighteen of saleable litharge, from twenty-two to twenty-three of cold litharge, from twenty to twenty-two quintals of impregnated test, and from six to seven quintals of lead-dross. The operation lasts from sixteen to eighteen hours. (o)

SMELT-

(o) Ores containing silver may be divided into four kinds. 1. *Pure*, or those which are not much compounded with other metals. 2. *Galenical*, in which the silver is mixed with much *galena* or ore of lead mineralised by sulphur. 3. *Pyritous*, in which the silver is mixed with the martial pyrites. 4. *Cupreous*; in which the silver is contained in copper-ores. To extract the silver from these several kinds of ores, different operations are necessary.

Native silver is separated from its adhering earths and stones by amalgamation with mercury, in the manner directed for the separation of gold; or by fusion with lead, from which it may be afterwards separated by cupellation.

Pure ores seldom require a previous calcination; but, when bruised and cleansed from extraneous matters, may be fused directly, and incorporated with a quantity of lead, unless they contain a large proportion of sulphur and arsenic; in which case a calcination may be useful. The lead employed must be in a calcined or vitrified state, which, being mixed with the ore, and gradually reduced by the phlogiston of the charcoal added to it, may be more effectually united with the silver of the ore, than if lead itself had been added, which would too quickly precipitate to the bottom of the containing vessel or furnace. The silver is to be afterwards separated from the lead by cupellation.

Galenical ores, especially those in which pyrites is intermixed, require a calcination, which ought to be performed in an oven, or reverberatory furnace. They are then to be fused together with some inflammable matter, as charcoal, by which the lead is revived, and, together with the silver, is precipitated.

Pyritous ores must be first melted, so as to form a matt. If the sulphur is not sufficient for this kind of fusion, more sulphurated pyrites may be added. This matt contains, besides silver and sulphur, also various metals, as lead, iron, and sometimes cobalt. The matt must be exposed to repeated calcinations till the sulphur is dissipated. By these calcinations most of the iron is destroyed. The calcined matt is to be fused with litharge, and the silver incorporated with the revived lead; from which, and

 from

SMELTING *of* ORES *of* COPPER.

The ſmelting in great of copper ores, and even of ſeveral ores of ſilver and lead, excepting that of Rammelſberg, is performed in furnaces not eſſentially different from that already deſcribed; but in this reſpect only, that the ſcoria

from the other imperfect metals with which it may be mixed, it muſt afterwards be ſeparated by cupellation. *See* REFINING.

The ſilver contained in *cupreous ores* may be obtained, either, 1. By ſeparating it from the copper itſelf, after this has been extracted along with the ſilver, in the uſual manner, from the ore; or, 2. By precipitating it immediately from the other matters of the ore.

1. It may be ſeparated from the copper by two methods. One of theſe is by adding lead, and ſcorifying the imperfect metals. By this method much of the copper would be deſtroyed, and it is therefore not to be uſed unleſs the quantity of ſilver relatively to the copper be conſiderable. Another method by which ſilver may be ſeparated from copper is, by *eliquation*; that is, by mixing the maſs of copper and ſilver with a quantity of lead, and applying ſuch a heat as ſhall be juſt ſufficient to make the lead eliquate from the copper, together with the ſilver, which being more ſtrongly diſpoſed to unite with the lead than with the copper, is thus incorporated with the former metal, and ſeparated from the latter. *See the article* ELIQUATION.

2. Silver may alſo be extracted from theſe cupreous ores by *precipitation*. For this purpoſe let the ore, previouſly bruiſed and cleanſed, be formed into a matt, that the earthy matters may be well ſeparated. Let the matt be then fuſed with a ſtrong heat; and when the ſcoria has been removed, and the heat is diminiſhed, add to it ſome clean galena, litharge, and granulated lead. When the fire has been raiſed, and the additions well incorporated with the matt, let ſome caſt or filed iron be thrown into the liquid maſs, which being more diſpoſed than lead is to unite with ſulphur, will ſeparate and precipitate the latter metal, and along with it the ſilver or gold contained in the matt. This method was introduced by Scheffer, and is practiſed at Adelfors in Smoland. In this work the proportion of the ſeveral materials is, four quintals of matt, two quintals of black copper containing ſome lead with the perfect metal, one quintal of galena, one quintal of litharge, a fifth part of a quintal of granulated lead, and an equal quantity of caſt iron.

The ſilver in this, and in all other inſtances where it is united with lead, is to be afterwards ſeparated from the lead by cupellation; which proceſs is deſcribed at the articles ESSAY *of the* VALUE *of* SILVER, *and* REFINING.

and metal are not drawn out of the furnace, but flow ſpontaneouſly, as ſoon as they are melted, into *receiving baſons*, where the metal is freed from the ſcoria. Theſe furnaces are generally called *pierced furnaces*.

Inſtead of a light braſque, or bed of charcoal-powder, under which the metal lies hid, the bottom of theſe furnaces is covered with a baſon compoſed of heavy braſque, which is a mixture of charcoal-powder and clay. In the front of the furnace, and at the bottom of the chemiſe, there is a hole, called the *eye*, through which the melted matter flows, and runs along a trench or furrow, called the *trace*, into one or more *receiving baſons*, made of earth, ſcoria, ſand, &c. There the metal is ſeparated from the ſcoria, by making it flow from theſe baſons into another lateral one. Theſe furnaces are alſo called *crooked furnaces*.

Different names are given to them according to ſome difference in their conſtruction. For inſtance, thoſe which have two *eyes*, and two *traces*, through which the melted matter flows alternately into two baſons, are called *ſpectacle-furnaces*. Their greater or leſs height gives occaſion alſo to the diſtinction of *high furnaces*, and *middle furnaces*.

The high furnaces are of modern invention. They were firſt introduced at Mansfeldt in the year 1727, and they are now uſed in almoſt all countries where ores are ſmelted, as in Saxony, Bohemia, Hungary, &c. Their chief advantage conſiſts in ſimplifying and diminiſhing the labor. This advantage is effected by the great height of the furnace, which allows the ore to remain there a long time before it falls down into the hotteſt part of the fire, and is melted. Conſequently, it ſuffers ſucceſſively different degrees of heat, and, before it is melted, it undergoes a roaſting which coſts nothing; therefore the high furnaces are chiefly employed for crude fuſions; and particularly for the ſlate copper-ore. Theſe furnaces are above eighteen feet high. A too great height is attended with an inconvenience, beſides the trouble of ſupplying it with ore and fuel, which is, that the charcoal is moſtly conſumed before it gets down where the greateſt heat is required, and is then rendered incapable of maintaining a fire ſufficiently intenſe.

All the furnaces which we have mentioned are ſupplied with large bellows, moved by the arbor of a wheel, which is turned round by a current of water.

The only kind of furnace for ſmelting ores where bellows are not employed, is what is called a *reverberatory*

furnace. The Germans call it a *wind-furnace*. It is also distinguished by the name of *English furnace*, because the invention of it is attributed to an English physician of the name of *Wright*, who was well versed in chemistry; and because the use of it was first introduced in England about the end of the last century, where it is much employed, as well as in several other countries, as at Konigsberg, in Norway. *See* PLATE II. *Fig.* 14. *and* 15.

The length of these furnaces is about eighteen feet, comprehending the masonry: their breadth is twelve feet, and their height nine feet and a half. The hearth is raised three feet above the level of the foundery: on one side is the fire-place, under which is an ash-hole hollowed in the earth; on the other side is a bason made, which is kept covered with fire when there is occasion: on the anterior side of this furnace there is a chimney, which receives the flame after it has passed over the mineral that is laid upon the hearth. This hearth, which is in the interior part of the furnace, is made of clay capable of sustaining the fire. The advantage of this furnace is, that bellows are not necessary, and consequently it may be constructed where there is no current of water, and wherever the mine happens to be. This furnace has a hole in its front through which the scoria is drawn out; and a bason, as we have said, on one side, made with sand, in which are oblong traces for the reception of the *matt*, and of the *black copper*, when they flow out of the furnace.

Copper is generally mineralised, not only by sulphur and arsenic, but also by semi-metals and pyritous matters, and is frequently mixed with other metals. As this metal has great affinity with sulphur and arsenic, it is almost impossible to disengage it from them entirely by roasting: hence in the smelting in great, nothing is obtained by the first operation but a copper-matt, which contains all the principles of the ore, excepting the earthy and stony parts, particularly when the ore is smelted, crude, and unroasted. Afterwards this matt must be again roasted and fused. The produce of this second fusion begins still more to resemble copper, but is not malleable. It continues mixed with almost all the minerals, particularly with the metals. As it is frequently of a black color, it is always called *black copper*, when it is unmalleable, whatever its color happens really to be.

As, of all the imperfect metals, copper is most difficultly burnt and scorified, it is again remelted several times, in order

order to burn and scorify the metallic substances mixed with it; and this is done till the copper is perfectly pure, which is then called *red*, or *refined copper*, and these last fusions are called the fining and refining of it: Red copper contains no metals but gold and silver, if any of these happened to be in the ore.

In order to avoid all these fusions, it has been proposed to treat in the humid way certain copper ores, particularly those which are very pyritous. This method consists in making blue vitriol from the ore, by roasting and lixiviating it, and in precipitating pure copper from this lixivium, which is called *cement-water*, by means of iron: but it is not much practised, because it has been observed, that all the copper contained in the ore was not procured by this means.

As expence is not much regarded in small essays and experiments, these fusions are much abridged and facilitated by adding at first saline and glassy fluxes; and then by refining the black copper with lead in the cupel, as gold and silver are done. In this method of refining, it is to be most carefully observed, that the metal be fused as quickly as possible, and exposed to no more heat than is necessary, lest it be calcined.

When the black copper contains some iron, but not a great deal, the lead presently separates the iron from it, and makes it rise to the surface of the copper: but if the iron be in too large a proportion, it prevents the lead from uniting with the copper. These two phenomena depend on the same cause, which is, that lead and iron cannot unite.

Frequently copper ores contain also a quantity of silver sufficient to make its extraction by particular processes profitable. It was long before any process could be thought of for this purpose which was not too expensive and troublesome; but at length it is accomplished by the excellent operation called *eliquation*. *See the word* ELIQUATION.

The copper from which silver has been separated by eliquation must be refined after this operation, as it is generally black copper from which silver is extracted; but even if it had not been black copper which was employed for this operation, it would require to be refined on account of a little lead it always retains. It is therefore carried to the refiners furnace, where this operation is performed by help of bellows, the blast of which is thrown upon the surface of the melted metal. As in this refining of copper the

the precise time when it becomes pure cannot be known, because scoria is always formed on its surface, it is necessary to use an *essay-iron*, the polished end of which being dipt in melted copper, shews that this metal is pure when the copper adhering to the iron falls off as soon as it is dipt in cold water.

When this mark of the purity of the copper has been observed, its surface ought to be well cleaned; and as soon as it begins to fix, it must be sprinkled with a broom or besom dipt in cold water. The surface of the copper which is then fixing, being suddenly cooled by the water, detaches itself from the rest of the metal, is taken hold of by tongs, and is thrown red-hot into cold water. By again sprinkling water on the mass of copper, it is all of it reduced into plates, which are called *rosettes*, and these plates are what is called *rosette-copper*. (p)

We

(p) The copper of pyritous cupreous ores cannot be obtained without several operations, which vary according to the nature of the ores. These operations are chiefly roastings and fusions. By the first fusion a matt is produced, which is afterwards to be roasted; and thus the fusions and roastings are to be alternately applied, till by the last fusion copper is obtained. These methods of treating pyritous copper ores depend on the two following facts: 1. Sulphur is more disposed to unite with iron than with copper. 2. The iron of these ores is destructible by the burning sulphur during the roasting or the fusion of the ores, while the copper is not injured. This fact appears from experiments mentioned by Scheffer and by Wallerius, and from the daily practice of smelting cupreous ores.

From these facts we learn, 1. That sulphur may be employed to separate and destroy iron mixed with copper; 2dly, that iron may be employed to separate the sulphur from copper, as is sometimes done in the essay of sulphurated copper-ores; and, 3dly, that by adjusting the proportion of the iron and sulphur to each other in the smelting of copper-ores, these two substances may be made to destroy each other, and to procure a separation of the copper; and this adjustment may be effected, by adding sulphur or sulphureous pyrites to the copper-ore, when the quantity of sulphur contained in this ore relatively to the iron is too small; or by adding iron when the sulphur predominates; or by roasting, by which the superfluous sulphur may be expelled, and no more left than is sufficient for the destruction of the iron contained in the ore. We shall apply these principles to the following cases.

1. When

We ſhall not enter into further details concerning the operations made in great upon the different minerals, that we may not exceed the bounds intended for this work. Beſides, what remains to be ſaid upon the ores of mercury, antimony, biſmuth, arſenic, and cobalt, is already ſufficiently explained in the different articles of this Dictionary relating to theſe ſubſtances, and to their products. The fuſion in great of ores of iron would indeed particularly deſerve to be treated more extenſively, on account of its importance; but we obſerve, that the general principles

1. When the quantity of ſulphur and of iron in a copper-ore is ſmall, and eſpecially when the iron does not too much abound, a previous roaſting will at once calcine the iron, and expel moſt of the ſulphur; ſo that by one fuſion the calcined iron may be ſcorified, and black copper may be obtained. If the ſulphur has not been ſufficiently expelled, a ſecond roaſting and fuſion are requiſite; for the whole quantity of ſulphur ought not to be expelled during the firſt roaſting; but as much ought to be left as is ſufficient for the ſcorification of the calcined iron, otherwiſe this might, during the fuſion, be again revived and united with the copper.

2. If, in a copper-ore, the quantity of iron be too great, relatively to the ſulphur, ſome ſulphurated pyrites, eſpecially that kind which contains copper, ought to be added, that a matt may be obtained, and that the iron may be calcined and ſcorified.

3. When the quantity of ſulphur and iron is very great, that is, when the ore is very pyritous and poor, it ought to be firſt formed into a matt; by which it is ſeparated from the adherent earths and ſtones, and the bulk is diminiſhed: then by repeated and alternate roaſtings and fuſions, the copper may be obtained.

4. When the quantity of ſulphur in an ore is greater than is ſufficient for the forming a matt, the ſuperfluous quantity ought to be previouſly expelled by roaſting.

The copper thus at firſt obtained is never pure, but is generally mixed with ſulphur or with iron. It is called *black copper*. This may be refined in furnaces, or on hearths.

In the former method, to the copper when melted a ſmall quantity of lead is added, which unites with the ſulphur, and is ſcorified together with the iron, and floats upon the ſurface of the melted copper. This purification of copper by means of lead is ſimilar to the refining of ſilver by cupellation, and is founded on the property of lead, by which it is more diſpoſed to unite with ſulphur than copper is, and on a property of copper, by which it is leſs liable than any other imperfect metal to be ſcorified by lead. But as copper is alſo capable of being ſcorified by lead,

ples of the ſmelting of ores contained in the preſent article are as applicable to ores of iron as of other metals, and for the particular details we are obliged to refer to good Treatiſes, which are not wanting on this ſubject, and particularly to the *Art of Forges and Iron-furnaces*, deſcribed moſt exactly by the Marquis de Courtivron, of the Royal Academy of Sciences, and by M. Bouchu, a correſpondent of that Academy; a work which makes part of a general deſcription of the Arts undertaken by that illuſtrious company. *(q)*

SNOW

lead, this operation muſt be no longer continued, and no more lead muſt be employed than is ſufficient for the ſeparation of the ſulphur, and for the ſcorification of the iron.

The copper might alſo be purified from any remaining ſulphur by adding a ſufficient quantity of iron to engage the ſulphur. Thus Mr. Scheffer found, that by adding to ſulphurated copper from $\frac{1}{20}$th to $\frac{1}{40}$th of old caſt iron, he rendered the copper pure and ductile. *See his Diſſertation on the Parting of Metals amongſt the Swediſh Memoirs for the year* 1752. In this purification, the quantity of iron added ought not to be too little, elſe all the ſulphur will not be ſeparated; and it ought not to be too great, elſe the ſuperfluous quantity will unite with and injure the purity of the copper. The fuſion and ſcorification, with addition of lead, ſeems to be the beſt method for the laſt purification of copper.

(q) In this work, which pretends to treat of the chemical principles of arts in general, we ought certainly not to omit ſome deſcription of the methods of procuring and manufacturing a metal, ſo extenſively uſeful, that without it no other art could have been perfected, and even, as ſome writers have obſerved, mankind could ſcarcely have been civilized.

In the article Iron, the author of the Dictionary has deſcribed the chemical properties of that metal, or its effects when acted upon by fire, acids, and other ſubſtances. The ſubjects of this note and of the article Steel are the proceſſes by which iron is obtained from its ores, and reduced to the ſeveral ſtates of *caſt iron*, *forged iron*, and *ſteel*, and the properties of this metal in theſe ſeveral ſtates, which render it fit for the various uſes to which it is daily applied.

Notwithſtanding the great importance of theſe ſubjects, and the labors of Reaumur, Swedenborgius, and of ſome other authors, we have ſtill a very imperfect knowledge of the cauſes of the differences of the ſeveral kinds of ores, of the methods of ſmelting beſt adapted to theſe differences, of the cauſes of the good and bad qualities of different kinds of iron, and of the

means

SNOW *of* ANTIMONY. The flowers of regulus of antimony are so called. *See* FLOWERS *of* REGULUS *of* ANTIMONY.

SOAP.

means of so meliorating this metal, that we may obtain tough and ductile iron from any of its ores.

Swedenborgius has very industriously and exactly described the different processes now used in most parts of Europe for the smelting of ores of iron, for the forging of that metal, and for the conversion of it into steel: but we do not find that he or any other author have, by experiments and discoveries, contributed much to the illustration or to the improvement of this part of metallurgy, unless, perhaps, we except those of Mr. Reaumur, concerning the softening of cast iron by cementation with earthy substances.

The *ores of iron* are known to vary much in their appearance, in their contents, in their degrees of fusibility, in the methods necessary for the extraction of their contained metal, and in the qualities of the metal when extracted.

Most ores require to be *roasted* previously to their fusion; some more slightly, and others with a more violent and longer-continued fire. Those which contain much sulphur, arsenic, or vitriolic acid, require a long-continued and repeated roasting, that the volatile matters may be expelled. Of this kind is the *black-iron ore*, from which the Swedish iron is said to be obtained.

Some ores require a very slight roasting only, that they may be dried and rendered friable. Such are the ores called *bog ores*, and others which being in a calcined state, and containing little sulphureous matter, would, by a further calcination, be rendered less capable of being reduced to a metallic state.

The roasting of ores of iron is performed by kindling piles, consisting of strata of fuel and of ore placed alternately upon one another, (*See* PLATE II. *Fig.* 11. *and* 12.) or in furnaces similar to those commonly employed for the calcination of limestone.

Some authors advise the addition of a calcareous earth to sulphureous ores during the roasting, that the sulphur may be absorbed by this earth when converted into quicklime. But we may observe, that the quicklime cannot absorb the sulphur or sulphureous acid, till these be first extricated from the ore, and does therefore only prevent the dissipation of these volatile matters; and, secondly, that the sulphur thus united with the quicklime forms a hepar of sulphur, which will unite with and dissolve the ore during its fusion, and prevent the precipitation of the metal.

The next operation is the *fusion* or *smelting* of the ore. This is generally performed in furnaces or towers, from twenty to thirty

SOAP. The name *soap* was formerly employed only to signify combinations of alkaline salts with oils, that is, compounds

thirty feet high, in the bottom of which is a bason for the reception of the fluid metal. *See a Section and Description of this Furnace in* PLATE II. *Fig.* 20. *and the Explanation of that Figure.* When the furnace is sufficiently heated, which must be done at first very gradually, to prevent the cracking of the walls; a quantity of the ore is to be thrown in, from time to time, at the top of the furnace, along with a certain quantity of fuel and of limestone, or whatever other flux is employed. While the fuel below is consumed by the fire excited by the wind of the bellows, the ore, together with its proportionable quantity of fuel and of flux, sink gradually down, till they are exposed to the greatest heat in the furnace. There the ore and the flux are fused, the metallic particles are revived by the fuel, are precipitated by means of their weight through the scoria formed of the lighter earthy parts of the flux and of the ore, and unite in the bason at the bottom of the furnace, forming a mass of fluid metal covered by a glassy scoria. When a sufficient quantity of this fluid metal is collected, which is generally twice or thrice in twenty-four hours, an aperture is made, through which the metal flows into a channel or groove made in a bed of sand; and from thence into smaller lateral or connected channels, or other moulds. There it is cooled, becomes solid, and retains the forms of the channels or moulds into which it flows. The piece of iron formed in the large channel is called *a sow*, and those formed in the smaller channels are called *pigs*. Sometimes the fluid iron is taken out of the furnace by means of ladles, and poured into moulds, ready prepared, of sand or of clay, and is thus formed into the various utensils and instruments for which cast iron is a proper material.

The *scoria* must be, from time to time, allowed to flow out, when a considerable quantity of it is formed, through an aperture made in the front of the furnace for that purpose. A sufficient quantity of it must, however, be always left to cover the surface of the melted iron, else the ore which would fall upon it, before the separation of its metallic from its unmetallic parts, would lessen the fluidity and injure the purity of the melted metal. This scoria ought to have a certain degree of fluidity; for if it be too thick, the revived metallic particles will not be able to overcome its tenacity, and collect together into drops, nor be precipitated. Accordingly, a scoria, not sufficiently fluid, is always found to contain much metal. If the scoria be too thin, the metallic particles of the ore will be precipitated before they are sufficiently metallized, and separated from the earthy and unmetallic parts. A due degree of fluidity is given to the scoria by

compounds in which oils are rendered miscible with water, by means of an alkali. But since chemists, by a more exact

by applying a proper heat, and by adding fluxes suited to the ore.

Some ores are fusible without addition, and others cannot be smelted without the addition of substances capable of facilitating their fusion.

The *fusible ores* are those which contain sulphur, arsenic, or are mixed with some fusible earth.

The *ores difficultly fusible* are, those which contain no mixture of other substance. Such are most of the ores which contain iron in a state nearly metallic. As iron itself, when purified from all heterogeneous matters, is scarcely fusible without addition, so the metal contained in these purer kinds of ores cannot be easily extracted without the addition of some fusible substance. 2. Those which are mixed with some very refractory substance. Some of these refractory ores contain arsenic; but as this substance facilitates the fusion of iron, we may presume that their refractory quality depends upon a mixture of some unmetallic earth or other unfusible substance. The earth which is mixed with the common calciform ores is in considerable quantity, and is sometimes calcareous, sometimes siliceous, and sometimes argillaceous.

Perhaps the fusibility of some ores depends greatly on the degree of calcination to which the metal contained in them has been reduced; since we have reason to believe that, by a very perfect calcination, some metals, at least, may be reduced to the state of an earth almost unfusible, and incapable of metallisation (*see the article* METALS); and since we know, that in every calcination and subsequent reduction of a given quantity of any imperfect metal, a sensible part of that quantity is always lost or destroyed, however carefully these operations may have been performed. That some of these ores are already too much calcined, appears from the instance above-mentioned of the *bog ores*, which are injured by roasting; and even the great height of the common smelting furnaces, although advantageous to many ores that require much roasting, is said to be injurious to those which are already too much calcined, by exposing them to a further calcination, during their very gradual descent, before they arrive at the hottest part of the furnace, where they are fused.

But, as too violent calcination renders some ores difficultly fusible; so too slight calcination of other ores injures the purity of the metal, by leaving much of the sulphureous or other volatile matter, which ought to have been expelled.

Various *substances are added to assist the fusion of ores* difficultly fusible. These are: 1. *Ores* of a fusible quality, or which, being mixed

exact examination of the nature of bodies, have discovered, that acids, and even other saline substances, may also be united

mixed with others of a very different quality, become fusible: accordingly, in the great works for smelting ores of iron, two or more different kinds of ore are commonly mixed, to facilitate the fusion, and also to meliorate the quality of the iron. Thus an ore yielding an iron which is brittle when hot, which quality is called *red-short*, and another ore which produces iron brittle when cold, or *cold-short*, are often mixed together; not, as is sometimes supposed, that these qualities are mutually destructive of each other, but that each of them is diminished in the mixed mass of iron, as much as this mass is larger than the part of the mass originally possessed of that quality. Thus, if from two such ores the mass of iron obtained consists of equal parts of cold-short and of red-short iron, it will have both these qualities, but will be only half as *cold-short* as iron obtained solely from one of the ores, and half as *red-short* as iron obtained only from the other ore. 2. *Earths* and *stones* are also generally added to facilitate the fusion of iron ores. These are such as are fusible, or become fusible when mixed with the ore, or with the earth adhering to it. Authors direct that, if this earth be of an argillaceous or siliceous nature, limestone or some calcareous earth should be added; and that if the adherent earth be calcareous, an argillaceous or siliceous earth should be added; because these two earths, though singly unfusible, yet, when mixed, mutually promote the fusion of each other: but as limestone is almost always added in the smelting of iron ores, and as in some of these, at least, no argillaceous or siliceous earth appears to be contained, I am inclined to believe, that it generally facilitates the fusion, not merely by uniting with those earths, but by uniting with that part of the ore which is most perfectly calcined, and least disposed to metallisation; since we know, that by mixing a calciform or roasted ore of iron with calcareous earth, without any inflammable matter, these two substances may be totally vitrified. *See Experiments made upon Quicklime, and upon Iron, by Mr. Brandt, in the Swedish Memoirs for the years* 1749 *and* 1751. Calcareous earth does indeed so powerfully facilitate the fusion of iron ores, that it deserves to be considered whether workmen do not generally use too great a quantity of it, in order to hasten the operation. For when the scoria is rendered too thin, much earthy or unmetallized matter is precipitated, and the cast-iron produced is of too vitreous a quality, and not sufficiently approximated to a true metallic state.

Some authors pretend, that a principal use of the addition of lime-stone in the smelting of iron-ores is to absorb the sulphur, or vitriolic acid, of these ores: but, as we have already observed, a hepar

united with oils, and may render these miscible with water, they have generalised the name of soap, and the best chemists give

a hepar of sulphur is formed by that mixture of calcareous earth and sulphur, which is capable of dissolving iron in a metallic state; and thus the quantity of metal obtained from an ore not sufficiently divested of its sulphur, or vitriolic acid, (which, by uniting with the fuel, is formed into a sulphur during the smelting) must be considerably diminished, though rendered purer by addition of calcareous earth: hence the utility appears of previously expelling the sulphur and vitriolic acid from the ore by a sufficient roasting. 3. The *scoria* of former smeltings is frequently added to assist the fusion of the ore; and, when the scoria contains much iron, as sometimes happens in ill-conducted operations, it also encreases the quantity of metal obtained.

The quantity of these fusible matters to be added varies according to the nature of the ore; but ought in general to be such, that the scoria shall have its requisite degree of thinness, as is mentioned above.

The *fuel* used in most parts of Europe for the smelting of ores of iron is charcoal. Lately, in several works in England and Scotland, iron-ore has been smelted by means of pitcoal, previously reduced to cinders or *coaks*, by a kind of calcination similar to the operation for converting wood into charcoal, by which the aqueous and sulphureous parts of the coal are expelled, while only the more fixed bituminous parts are left behind. In France pitcoal not calcined has been tried for this purpose, but unsuccessfully. The use of *peat* has also been introduced in some parts of England.

The quality of the iron depends considerably upon the quality and also upon the quantity of the fuel employed. Charcoal is fitter than coaks for producing an iron capable of being rendered malleable by forging.

The quantity of fuel, or the intensity of the heat, must be suited to the greater or less fusibility of the ore. Sulphureous and other ores easily fusible, require less fuel than ores difficultly fusible. In general, if the *quantity of fuel be too small*, and the heat not sufficiently intense, all the iron will not be reduced, and much of it will remain in the scoria, which will not be sufficiently thin. This defect of fuel may be known by the blackness and compactness of the scoria, by the qualities of the iron obtained, which in this case is hard, white, light, intermixed with scoria, smooth in its texture, without scales or grains, rough and convex in its surface, and liable to great loss of weight by being forged: and, lastly, it may be known by observing the color and appearance of the drops of metal falling down from the smelted ore, and of the scoria upon the surface of the fluid metal, both which

give it now to all combinations of any ſaline ſubſtances with oils, rendered miſcible with water by means of theſe ſaline ſubſtances

which are darker colored than when more fuel is uſed. When the *quantity of fuel is ſufficiently large*, and the heat is intenſe enough, the iron is darker-colored, denſer, more tenacious, contains leſs ſcoria, and is therefore leſs fuſible, and loſes leſs of its weight by being forged. Its ſurface is alſo ſmoother and ſomewhat concave; and its texture is generally granulated. The ſcoria, in this caſe, is of a lighter color and leſs denſe. The drops falling from the ſmelted ore, and the liquid ſcoria in the furnace, appear hotter and of a brighter color. When the quantity of fuel is too great, and the heat too intenſe, the iron will appear to have a ſtill darker color, and more conſpicuous grains or plates, and the ſcoria will be lighter, whiter, and more ſpungy. The drops falling from the ſmelted ore, and the fluid ſcoria, will appear to a perſon looking into the furnace through the blaſt-hole to be very white and ſhining hot. The quantity of charcoal neceſſary to produce five hundred weight of iron, when the ore is rich, the furnace well contrived, and the operation ſkilfully conducted, is computed to be about forty cubic feet; but is much more in contrary circumſtances.

The *time, during which the fluid metal ought to be kept in fuſion* before it is allowed to flow out of the furnace, muſt be alſo attended to. How long that time is, and whether it ought not to vary according to the qualities of ores and other circumſtances, I cannot determine. In ſome works the metal is allowed to flow out of the furnace every ſix or eight, and in others only every ten or twelve hours. Some workmen imagine, that a conſiderable time is neceſſary for the concoction of the metal. This is certain, that the iron undergoes ſome change by being kept in a fluid ſtate; and that if its fuſion be prolonged much beyond the uſual time, it is rendered leſs fluid, and alſo its coheſion, when it becomes cold, is thereby greatly diminiſhed. The Marquis de Courtivron ſays, that the coheſion may be reſtored to iron in this ſtate, by adding to it ſome vitreſcible earth, which he conſiders as one of the conſtituent parts of iron, and which he thinks is deſtroyed by the fuſion too long continued. That the fuſibility of caſt iron does depend on an admixture of ſome vitreſcible earth, appears probable from the great quantity of ſcoria forced out of iron during its converſion into malleable or forged iron, and from the loſs of fuſibility which it ſuffers nearly in proportion to its loſs of ſcoria. The quantity of iron daily obtained from ſuch a furnace as is above deſcribed, is from two to five tons in twenty-four hours, according to the richneſs and fuſibility of the ore, to the conſtruction of the furnace, to the adjuſtment of the due quantity of flux and of fuel, and to the ſkill employed in conducting the operation.

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substances. The vegetable kingdom contains many such saline, oily combinations soluble in water. All vegetable acids,

The *quality of the iron* is judged by observing the appearances during its flowing from the furnace; and when it is fixed and cold. If the fluid iron, while it flows, emits many and large sparkles; if many brown spots appear on it while it is yet red-hot; if when it is fixed and cold, its corners and edges are thick and rough, and its surface is spotted; it is known to have a red-short quality. If, in flowing, the iron seems covered with a thin glassy crust, and if, when cold, its texture be whitish, it is believed to be cold-short. Mr. Reaumur says, that dark-colored cast-iron is more impure than that which is white. The Marquis de Courtivron is of a contrary opinion. But no certain rules for judging of the quality of iron before it be forged can be given. From brittle cast-iron, sometimes ductile forged iron is produced. Cast-iron with brilliant plates and points, when forged, becomes sometimes red-short and sometimes cold-short. Large shining plates, large cavities called *eyes*, want of sufficient density, are almost certain marks of bad iron; but whether it will be cold or red-short cannot be affirmed till it be forged. Whiteness of color, brittleness, closeness of texture, and hardness, are given to almost any cast-iron by sudden cooling; and we may observe, that in general the whiter the metal is, the harder it is also, whether these properties proceed from the quality of the iron, or from sudden cooling; and that, therefore, the darker-colored iron is fitter for being cast into moulds, because it is capable in some measure of being filed and polished, especially after it has been exposed during several hours to a red-heat in a reverberatory furnace, and very gradually cooled. This operation, called by workmen *annealing*, changes the texture of the metal, renders it softer, and more capable of being filed than before, and also considerably less brittle.

Mr. Reaumur found, that by cementing cast-iron with absorbent earths in a red-heat, the metal may be rendered softer, tougher, and consequently a fit material for many utensils formerly made of forged iron. Whether cementation with absorbent earths gives to cast-iron a greater degree of these properties than the annealing commonly practised, has not been yet determined.

In Navarre, and in some of the southern parts of France, iron-ore is smelted in furnaces much smaller, and of a very different construction from those above-described. A furnace of this kind consists of a wide-mouthed copper-caldron, the inner surface of which is lined with masonry a foot thick. The mouth of the caldron is nearly of an oval or elliptic form. The space or cavity contained by the masonry is the furnace in which the ore is smelted. The depth of this cavity is equal to two feet and a half: the larger diameter of the oval mouth of the cavity is about eight feet, and

acids, fluor or concrete; essential salts; saccharine juices; the extractive matter of plants, properly so called, are sapo-
naceous

and its smaller diameter is about six feet: the space of the furnace is gradually contracted towards the bottom, the greatest diameter of which does not exceed six feet: eighteen inches above the bottom is a cylindrical channel in one of the longer sides of the caldron and masonry, through which the nozzle of the bellows passes. This channel, and also the bellows-pipe, are so inclined, that the wind is directed towards the lowest point of the opposite side of the furnace. Another cylindrical channel is in one of the shorter sides of the furnace, at the height of a few inches from the bottom, which is generally kept closed, and is opened occasionally to give passage to the scoria; and above this is a third channel, in the same side of the furnace, through which an iron instrument is occasionally introduced to stir the fluid metal, and to assist, as is said, the separation of the scoria from it. The greatest height of this channel is at its external aperture on the outside of the furnace, and its smaller height is at its internal aperture; so that the instrument may be directed towards the bottom of the furnace; but the second channel below it has a contrary inclination, that when an opening is made, the scoria may flow out of the furnace into a bason placed for its reception. When the furnace is heated sufficiently, the workmen begin to throw into it alternate charges of charcoal, and of ore previously roasted. They take care to throw the charcoal chiefly on that side at which the wind enters, and the ore at the opposite side. At the end of about four hours a mass of iron is collected at the bottom of the furnace, which is generally about six hundred weight: the bellows are then stopt; and when the mass of iron is become solid, the workmen raise it from the bottom of the furnace, and place it, while yet soft, under a large hammer, where it is forged. The iron produced in these furnaces is of the best quality; the quantity is also very considerable, in proportion to the quantity of ore, and to the quantity of fuel employed. In these furnaces no limestone or other substance is used to facilitate the fusion of the ore. We should receive much instruction concerning the smelting of iron-ore, if we knew upon what part of the process or circumstance, the excellence of the iron obtained in these furnaces depends; whether on the quality of the ore; on the disuse of any kind of flux, by which the proportion of vitreous or earthy matter, intermixed with the metallic particles, is diminished; on the forging while the iron is yet soft and hot, as the Marquis de Courtivron thinks; or on some other cause, not observed.

The iron thus produced by smelting ores is very far from being a pure metal; and though its fusibility renders it very useful for the formation of cannon, pots, and a great variety of utensils, yet

 it

naceous substances, or acid soaps. In many of these soaps, such as essential salts and vegetable acids, the saline part

it wants the strength, toughness, and malleability, which it is capable of receiving by further operations.

Cast-iron seems to contain a large quantity of vitreous or earthy matter mixed with the pure iron; which matter is probably the chief cause of its fusibility, brittleness, hardness, and other properties by which it differs from forged iron. The sulphur, arsenic, and other impurities of the ores, which are sometimes contained in cast-iron, are probably only accidental, and may be the causes of the red-short quality, and of other properties of certain kinds of iron: but the earthy matter above-mentioned seems principally to distinguish cast-iron from forged or malleable iron; for, first, by depriving the former of this earthy matter, it is rendered malleable, as in the common process hereafter to be described; and, secondly, by fusing malleable iron with earthy and vitrescible matters, it loses its malleability, and is restored to the state and properties of cast-iron.

The earthy vitreous matter contained in cast-iron consists probably of some of the ferruginous earth or calx of the ore not sufficiently metallised, and also of some unmetallic earth. Perhaps it is only a part of the scoria which adheres to, and is precipitated with, the metallic particles, from which it is more and more separated, as the heat applied is more intense, and as the fusion is longer continued.

To separate these impurities from cast-iron, and to unite the metallic parts more closely and compactly, and thus to give it the ductility and tenacity which render this metal more useful than any other, are the effects produced by the following operations.

The first of these operations is a fusion of the iron, by which much of its impurities is separated in form of scoria; and by the second operation, a further and more compleat separation of these impurities, and also a closer compaction of the metallic particles, are effected by the application of mechanical force or pressure, by means of large hammers.

Some differences in the construction of the forge or furnace, in which the *fusion* or *refining of cast-iron* is performed, in the method of conducting the operation, and in some other circumstances, are observed to occur in different places. We shall describe, from Suedenborgius, the *German method*.

The fusion of the cast-iron, which is to be rendered malleable, is performed upon the hearth of a forge similar to that used by blacksmiths: at one side of this hearth is formed a cavity or fire-place, which is intended to contain the fuel and the iron to be melted: this fire-place is twenty inches long, eighteen inches broad, and twelve or fourteen inches deep; it is bounded on

 three

part predominates over the oily part, and they have therefore been considered rather as salts, than as soaps. But the oil contained

three sides by three plates of cast-iron placed upright; and on the fourth side, which is the front, or that part nearest to which the workmen stand, by a large forge-hammer, through the eye of which the scoria is at certain times allowed to flow. The floor also of the fire-place is another cast-iron plate. The thickness of these plates is from two to four inches. One of the upright side-plates rests against a wall, in an aperture through which a copper tube, called the *tuyere*, is luted with clay. This tube is a kind of case or covering for the pipe of a pair of bellows placed behind the wall, and its direction is therefore parallel to that of the bellows-pipe; but it advances about half a foot further than this pipe into the fire-place; and thus gives greater force to the air, which it keeps concentrated, or prevents the divergency of the air, till it is required to act. The tube rests upon the upper edge of the side-plate which leans against the wall, nearer to the back part than to the front of the fire-place, and in such an oblique direction, that the wind shall be impelled towards the furthest part of the floor of the fire-place, or where this floor is intersected by the opposite side-plate. The obliquity of the tuyere ought to vary according to the quality of the iron: and therefore, in every operation, it may be shifted till its proper position is found. The more nearly its direction approaches to a horizontal plane, the more intense is the heat; but a larger quantity of fuel is consumed than is even proportional to the encrease of heat, because the flame is not then so well confined. When the iron is easily fusible, great heat is not required: the tuyere may then decline considerably from the horizontal plane, and thus fuel may be saved. This tuyere, though made of copper, a metal more easily fusible than iron, is preserved from fusion by the constant passage of cold air through it. It must be carefully kept open, and cleansed from the scoria, which would be apt to block its cavity, by which not only the heat would be too much diminished for the success of the operation, but the tube itself would be melted.

To prepare for the fusion, a quantity of scoria of a former operation is thrown into the fire-place, till one-third part of this be full; and the remaining two-thirds of the fire-place are to be filled with smaller scoria, coal-dust, and sparks ejected from hot iron. These matters, being fusible, form a bath for the reception of the iron when melted. Upon this bed of scoria, the mass of cast-iron to be melted is placed; so that one end of it shall be within the fire-place, opposite to the tuyere, and at the distance of about four or five inches from its aperture; and the other end shall stand without the fire-place, to be pushed in, as the former is melted. The upper side of the mass of iron ought to be in the same horizontal plane

contained in all these compounds is rendered perfectly miscible with water by means of the saline matter, and it is consequently in a state truly saponaceous.

We

plane as the upper part of the orifice of the tuyere, that the wind may, by means of the obliquity of its course, strike upon and pass along the under-side of the mass: but if the iron be difficultly fusible, the tuyere is to be disposed more horizontally, so that the wind shall strike directly upon the mass of iron; and that one part of the blast shall graze along the upper surface, and the other part along the under surface of the iron. The mass of iron weighs generally from two hundred to four hundred pounds. Sometimes two or three smaller masses are put one above another, so as not to touch. When these are of different qualities, the cold-short piece is placed undermost, that being more unfusible than the red-short. The iron being placed, charcoal-powder is thrown on both sides, and coals are accumulated above, so as to cover entirely the iron.

The coals are then to be kindled, and the bellows are made to blow, at first slowly, and afterwards with more and more force. The iron is gradually liquefied, and flows down in drops through the melted scoria to the bottom of the fire-place; during which the workmen frequently turn the iron, so that the end opposed to the blast of wind may be equally exposed to heat, and uniformly fused. While the coals are consumed, more are thrown on, so that the whole may be kept quite covered. During the operation, a workman frequently sounds the bottom and corners of the fire-place, by means of a bar or poker, raises up any mass of metal which he finds adhering to these, and exposes them to the greatest heat, that they may be more perfectly fused.

When all the iron is fused, no more coals are to be added; but the melted mass is to remain half uncovered for some time; during which the iron boils and bubbles, and its surface swells and rises higher and higher. When the iron has risen as high as the upper edge of the fire-place, the coals upon its surface must be removed; and by thus exposing it to cold air, its ebullition and swelling subside. In this state, or coction, the iron is kept during half an hour or more, by adding occasionally pieces of good coal, which maintain a sufficient heat, without covering entire the surface of the mass. During this coction, the workmen allow the orifice of the tuyere to be half stopped up by the scoria, that the air may not blow upon the iron with all its force, by which it would be too much cooled. Accordingly, when they think that the coction has continued sufficiently long, they clear the passage of the tuyere, and the mass is soon cooled by the cold air. At the same time also, they open a passage in the eye of the hammer placed in the front of the fire-place, through which some of the scoria is allowed to flow out. When the iron has become solid, the bel-

 lows

We may also combine acids directly with oils, and thus may form artificially acid soaps. But these operations are difficult,

lows are stopt, the coals are removed, and the mass is left during an hour; and then the workmen raise it from the fire-place, turn it upside down, and proceed to the second coction or fusion of the iron.

For this second operation, the mass is to be so placed, that one part of it shall rest upon the tuyere, and the other upon the scoria remaining in the fire-place. This scoria is to be disposed in an oblique direction parallel to the tuyere, by which means the wind of the bellows is obliged to pass all along the under side of the mass of iron. About the sides of the mass, charcoal-powder and burnt ashes are thrown; but towards the tuyere, dry and entire pieces of coals are placed to maintain the fire. When these are kindled, more coals are added, and the fire is gradually excited. The workman attends to the direction of the flame, that it pass equally along the under surface of the iron, quite to the further extremity, and that it do not escape at the sides, nor be reverberated back towards the tuyere, by which this copper tube might be melted. During this fusion, pieces of iron are apt to be separated from the mass, and to fall down unfused to the bottom and corners of the fire-place. These are carefully to be searched for, and exposed to the greatest heat till they are melted. When the whole mass is thus brought into perfect fusion, the coals are removed, and the wind blowing on its surface, whirls and dissipates the small remaining pieces of scoria, and sparks thrown out from the fluid iron. This jet of fire continues about seven or eight minutes, and the whole operation about two hours. In this second fusion the scoria is to be thrice removed, by opening a passage through the eye of the hammer. The first time of removing the scoria is about twenty minutes from the kindling of the fire; the second time is about forty minutes after the first; and the third time is near the end of the operation.

The mass is then removed from the hearth, and put upon the ground of the forge, where it is cleansed from scoria, and beat into a more uniform shape. It is then placed on an anvil, where, by being forged, it receives a form nearly cubical. This mass is to be divided into five, six, or more pieces, by means of a wedge; and these are to be heated and forged till they are reduced to the form of the bars commonly sold.

In some forges, the iron is fused only once, and in others it suffers three fusions, by which it is said to be rendered very pure. Where only one fusion is practised, it is called the *French method*. In this, no greater quantity of iron is fused at once than is sufficient to make one bar. The fire-place is of considerably less dimensions, and especially is less deep than in the German method

difficult, and exhibit many ſingular appearances, according to the ſtate and nature of the acids and oils combined. Vitriolic

thod above deſcribed. The fire is alſo more intenſe, and the proportion of fuel conſumed to the iron is greater. The iron, when melted, is not kept in a ſtate of ebullition, as is above deſcribed; but this ebullition is prevented by ſtirring the fluid maſs with an iron bar, till it is coagulated, and becomes ſolid.

By theſe operations, fuſion and forging, the iron loſes about $\frac{2}{15}$ parts of its former weight, ſometimes more and ſometimes leſs, according to the quality of the caſt-iron employed; it is purified from the vitreous and earthy parts which were intermixed with it, its metallic particles are more cloſely compacted, its texture is changed, and it is rendered more denſe, ſoft and malleable, tough and difficultly fuſible.

The degrees however of theſe qualities vary much in different kinds of iron. Thus ſome iron is tough and malleable, both when it is hot and when it is cold. This is the beſt and moſt uſeful iron. It may be known generally by the equable ſurface of the forged bar, which is free from tranſverſe fiſſures or cracks in the edges, and by a clear, white, ſmall-grained, or rather fibrous texture. Another kind is tough when it is heated, but brittle when it is cold. This is called *cold-ſhort* iron, and is generally known by a texture conſiſting of large, ſhining plates, without any fibres. It is leſs liable to ruſt than other iron. A third kind of iron called *red-ſhort*, is brittle when hot, and malleable when cold. On the ſurface and edges of the bars of this kind of iron, tranſverſe cracks or fiſſures may be ſeen; and its internal color is dull and dark. It is very liable to ruſt. Laſtly, ſome iron is brittle both when hot and when cold.

Moſt authors agree, that the red-ſhort quality of iron proceeds from ſome ſulphur or vitriolic acid being contained in it, becauſe ſulphur is known to produce this effect when added to iron; and becauſe the iron obtained from pyritous and other ſulphurated ores has generally this quality.

The cauſe of the cold-ſhort quality of iron is not ſo well aſcertained. Some imagine that it proceeds from a mixture of arſenic or of antimony. But this opinion ſeems to be improbable, when we conſider that theſe metallic ſubſtances may in a great meaſure be diſſipated by roaſting, whereas the ores which yield a cold-ſhort iron are injured by much roaſting; that no arſenic or antimony are obſervable in moſt, if in any, of theſe ores; and laſtly, that theſe ſemi-metals would render the iron brittle both when hot and when cold. Cramer and other authors impute this vicious quality to a mixture of an unmetallic earth or vitreous matter, and affirm that it may be deſtroyed by cementation with phlogiſton, and by forging. And laſtly, others aſcribe the cold-ſhort quality of iron to a defect of phlogiſton, or, as Suedenborgius

Vitriolic and nitrous acids, eſpecially when well concentrated, act ſo powerfully upon all drying, ſweet, or eſſential oils,

ſays, of ſulphur. To aſcertain the cauſes of the bad qualities of iron, and to diſcover practicable remedies, are ſtill deſiderata in metallurgy.

In one bar frequently two or more different kinds of iron may be obſerved, which run all along its whole length; and ſcarcely a bar is ever found of entirely pure and homogeneous iron. This difference probably proceeds from the practice we have mentioned of mixing different kinds of ores together, in the ſmelting; and alſo from the practice of mixing two or more pigs of caſt-iron of different qualities in the finery of theſe; by which means, the red-ſhort and the cold-ſhort qualities of the different kinds are not, as we have already remarked, mutually counteracted or deſtroyed by each other, but each of theſe qualities is diminiſhed in the mixed maſs of iron, as much as this maſs is larger than the part of the maſs originally poſſeſſed of that quality: That is, if equal parts of red ſhort and of cold-ſhort iron be mixed together; the mixed maſs will be only half as red-ſhort as the former part, and half as cold-ſhort as the latter. For theſe different kinds of iron ſeem as if they were only capable of being interwoven and diffuſed through each other, but not of being intimately united or combined.

The quality of forged iron may be known by the texture which appears on breaking a bar. The beſt and tougheſt iron is that which has the moſt fibrous texture, and is of a clear greyiſh color. This fibrous appearance is given by the reſiſtance which the particles of the iron make to their rupture. The next beſt iron is that whoſe texture conſiſts of clear, whitiſh, ſmall grains, intermixed with fibres. Theſe two kinds are malleable, both when hot and when cold, and have great tenacity. *Cold ſhort iron* is known by a texture conſiſting of large, ſhining plates, without fibres: and *red-ſhort iron* is diſtinguiſhed by its dark dull color, and by the tranſverſe cracks and fiſſures on the ſurface and edges of the bars. The quality of iron may be much improved by violent compreſſion, as by forging and rolling; eſpecially when it is not long expoſed to too violent heat, which is known to injure, and at length to deſtroy its metallic properties.

Of the SMELTING *of* TIN-ORES.

The tin-ores commonly ſmelted, are thoſe which conſiſt of calx of tin combined with calx of arſenic, and ſometimes with calx of iron. Theſe are either pure, as the tin-grains, or intermixed with ſpars, ſtones, pyrites, ores of copper, iron, or of other metals.

The impure ores muſt be *cleanſed* as much as is poſſible from all heterogeneous matters. This cleanſing is more neceſſary in ores of

oils, that they produce confiderable alterations. Nitrous acid inflames them, or, when not fufficiently concentrated to

of tin than of any other metal, becaufe in the fmelting of tin-ores a lefs intenfe heat muft be given than is fufficient for the fcorification of earthy matters, left the tin be calcined. Tin-ores previoufly bruifed may be cleanfed by wafhing, for which operation their great weight and hardnefs render them well adapted. If they be intermixed with very hard ftones or ferruginous ores, a flight roafting will render thefe impure matters more friable, and confequently fitter to be feparated from the tin-ores. Sometimes thefe operations, the roafting, contufion, and lotion, muft be repeated. By roafting, the ferruginous particles are fo far revived, that they may be feparated by magnets.

The ore, thus cleanfed from adhering heterogeneous matters, is to be *roafted* in an oven or reverberatory furnace with a fire rather intenfe than long continued, during which it muft be frequently ftirred to prevent its fufion. By this operation the arfenic is expelled, and in fome works is collected in chambers built purpofely above the calcining furnace.

Laftly, The ore cleanfed and roafted is to be *fufed*, and reduced to a metallic ftate. In this fufion, attention muft be given to the following particulars. 1. No more heat is to be applied than is fufficient for the reduction of the ore, becaufe this metal is fufible with very little heat, and is very eafily calcinable. 2. To prevent this calcination of the reduced metal, a larger quantity of charcoal is ufed in this than in moft other fufions. 3. The fcoria muft be frequently removed, left fome of the tin fhould be involved in it, and the melted metal muft be covered with charcoal-powder to prevent the calcination of its furface. 4. No flux or other fubftance, excepting the fcoria of former fmeltings which contains fome tin, are to be added, to facilitate the fufion.

SMELTING *of* ORES *of* LEAD.

Ores of lead are either *pure*, that is, containing no mixture of other metal, or they are *mixed* with filver, copper, or pyrites. The methods of treating ores of lead containing filver and copper, are defcribed in the articles SMELTING *of* ORES *of* SILVER *and of* COPPER; and in the former of thefe articles, an inftance is given of the method of fmelting the ore of Rammelfberg, which contains all thefe three metals.

Pure ores of lead, and thofe which contain fo fmall a quantity only of filver as not to compenfate for the expence of extracting the nobler metal, may be fmelted in furnaces, and by operations fimilar to thofe ufed at Rammelfberg, or in the following methods. 1. From the lead-ore of *Willach* in *Carinthia*, a great part of the lead

to produce this inflammation, it reduces them, as the vitriolic acid alſo does, into thick, reſinous, and bituminous

lead is obtained by a kind of *eliquation*, during the roaſting of the ore. For this purpoſe, the ore is thrown upon ſeveral ſtrata or layers of wood, placed in a calcining or reverberatory furnace. By kindling this wood, a great part of the lead flows out of the ore, through the layers of fuel, into a baſon placed for its reception. The ore which is thus roaſted is beat into ſmaller pieces, and expoſed to a ſecond operation ſimilar to the former, by which more metal is eliquated; and the remaining ore is afterwards ground, waſhed, and ſmelted in the ordinary method.

The lead of Willach is the pureſt of any known. Schlutter aſcribes its great purity to the method uſed in extracting it, by which the moſt fuſible, and conſequently the pureſt part of the contained lead is ſeparated from any leſs fuſible metal which happens to be mixed with it, and which remains in the roaſted ore. This method requires a very large quantity of wood.

2. In England, lead-ores are ſmelted either *upon a hearth*, or *in a reverberatory furnace*, called *a cupel*.

In the firſt of theſe methods, charcoal is employed as fuel, and the fire is excited by bellows. Small quantities of fuel and of ore are thrown alternately and frequently upon the hearth. The fuſion is very quickly effected; and the lead flows from the hearth as faſt as it is ſeparated from the ore.

3. In the ſecond method practiſed in England, pit-coal is uſed as fuel. The furnace is repreſented by *Fig.* 14. *and* 15. PLATE II. The ore is melted by means of the flame paſſing over its ſurface; its ſulphur is burnt and diſſipated, while the metal is ſeparated from the ſcoria, and collected at the bottom of the furnace. When the ore is well cleanſed and pure, no addition is requiſite; but when it is mixed with calcareous or earthy matrix, a kind of fluor or fuſible ſpar found in the mines is generally added, to render the ſcoria more fluid, and thereby to aſſiſt the precipitation of the metal. When the fuſion has been continued about eight hours, a paſſage in the ſide of the furnace is opened, through which the liquid lead flows into an iron ciſtern. But immediately before the lead is allowed to flow out of the furnace, the workmen throw upon the liquid maſs a quantity of ſlaked quicklime, which renders the ſcoria ſo thick and tenacious, that it may be drawn out of the furnace by rakes. Schlutter mentions this addition of quicklime in the ſmelting of lead-ores in England, but thinks that it is intended to facilitate the fuſion of the ores, whereas it really has a contrary effect, and is never added till near the end of the operation, when the ſcoria is to be raked from the ſurface of the metal.

Of

nous compounds. The action of these acids appears less strong upon the fat oils, which do not dry, and are capable of

Of the SMELTING of ORES of SEMI-METALS.

Antimony is obtained by a kind of eliquation from the minerals containing it, as is described in the article Antimony: and the regulus of antimony is procured from antimony, by the processes described in the same *article*, and in the article Regulus of Antimony.

Arsenic, Saffre, and Bismuth are obtained generally from one ore, namely, that called *cobalt*. The arsenic of the ore is separated by roasting, and adheres to the internal surface of a chimney, which is extended horizontally about two or three hundred feet in length, and in the sides of which are several doors, by means of which the arsenic, when the operation is finished, may be swept out and collected. These chimneys are generally bent, in a zig-zag direction, that they may better retard and stop the arsenical flowers. These flowers are of various colors, white, grey, red, yellow, according to the quantity of sulphur or other impurity with which they happen to be mixed. They are afterwards purified by repeated sublimations; while some alkaline or other substances are added to detain the sulphur, and to assist the purification.

In the same roasting of the ore by which the arsenic is expelled, the bismuth, or at least the greatest part of this semi-metal which is contained in the ore, being very fusible, and having no disposition to unite with the regulus of cobalt, which remains in the ore, is separated by eliquation.

The remaining part of the roasted ore consists chiefly of calx of regulus of cobalt, which not being volatile, as the arsenic is, nor so easily fusible as bismuth is, has been neither volatilized nor melted. It contains also some bismuth, and a small quantity of arsenic, together with any silver or other fixed metal which happened to be contained in the ore. This roasted ore being reduced to a fine powder, and mixed with three or four times its weight of fine sand, is the powder called *saffre* or *zaffre*. *See* Saffre. Or the roasted ore is sometimes fused with about thrice its quantity of pure sand and as much pure potash, by which a blue glass, called *smalt*, is produced (*see* Smalt), and a metallic mass, called *speiss*, is collected at the bottom of the vessel in which the matters are fused. The metallic mass or speiss is composed of very different substances, according to the contents of the ore, and the methods of treating it. The matters which it contains at different times are, nickel, regulus of cobalt, bismuth, arsenic, sulphur, copper, and silver.

Bismuth is seldom procured from any other ores but that of cobalt. It might however be extracted from its proper ores, if a sufficient

of forming with them true acid ſoaps. But all theſe matters have been but ſuperficially examined, and may be conſidered, by perſons deſirous of extending chemical knowledge, as a new ſubject.

SOAP (COMMON). Common ſoap is a combination of oil of olives with fixed alkali rendered cauſtic by

ficient quantity of theſe were found, by the ſame method by which it is obtained from cobalt, namely, by eliquation.

MERCURY, when native and inveloped in much earthy or other matter, from which it cannot be ſeparated merely by waſhing, is diſtilled either by aſcent, or by deſcent. When it is mineraliſed by ſulphur, that is, when it is contained in cinnabar, ſome intermediate ſubſtance, as quicklime, or iron, muſt be added in the diſtillation, to diſengage it from the ſulphur. *See* CINNABAR. The rich ore of Almaden in Spain is a cinnabar, with which a calcareous ſtone happens to be ſo blended, that no addition is required to diſengage the mercury from the ſulphur. The diſtillation is there performed in a furnace conſiſting of two cavities, one of which is placed above another. The lower cavity is the fire-place, and contains the fuel, reſting upon a grate, through the bars of which the air enters, maintains the fire, and paſſes into a chimney, placed at one ſide of the fire-place, immediately above the door through which fuel is to be introduced. The roof of this fire-place, which is vaulted and pierced with ſeveral holes, is alſo the floor of the upper cavity. Into this upper cavity the mineral from which mercury is to be diſtilled is introduced, through a door in one of the ſides of the furnace. In the oppoſite wall of this cavity are eight openings, all at the ſame height. To each of theſe openings is adapted a file of aludels connected and luted together, extending ſixty feet in length. Theſe aludels, which are earthen veſſels open at each end, and wider in the middle than at either extremity, (*ſee* ALUDEL *and* PLATE I.) are ſupported upon an inclined terras; and the aludel of each file, that is moſt diſtant from the furnace, terminates in a chamber built of bricks, which has two doors, and two chimneys.

When the upper cavity is filled ſufficiently with the mineral, a fire is made below, which is continued during twelve or fourteen hours. The heat is communicated through the holes of the vaulted roof of the fire-place to the mineral in the upper cavity, by which means the mercury is volatiliſed, and its vapor paſſes into the aludels, where much of it is condenſed, and the reſt is diſcharged into the brick-chamber, in which it circulates till it alſo is condenſed. If any air or ſmoke paſſes through the aludels along with the vapor of the mercury, they eſcape through the two chimneys of the chamber. Three days after the operation, when the apparatus is ſufficiently cooled, the aludels are unluted, the doors of the chamber are opened, and the mercury is collected.

quicklime

quicklime. Soap may be made by ſeveral methods, which however all depend upon the ſame principle. The ſoap which is uſed in medicine is made without heat in the following manner.

One part of quicklime and two parts of good Spaniſh ſoda are boiled together, during a ſhort time, with twelve times as much water, in an iron caldron. This lixivium is to be filtered, and evaporated by heat, till a phial which is capable of containing an ounce of water, ſhall contain an ounce and three gros of this concentrated lixivium. One part of this lixivium is to be mixed with two parts of oil of olives, or of ſweet almonds, in a glaſs or ſtone-ware veſſel. The mixture is to be ſtirred from time to time with an iron ſpatula, or with a peſtle, and it ſoon becomes thick and white. The combination is gradually compleated, and in ſeven or eight days a very white and firm ſoap is obtained.

Soap is made with heat in manufactures where large quantities of it are prepared. A lixivium of quicklime and ſoda is made, but is leſs concentrated than that above deſcribed, and only ſo much that it can ſuſtain a freſh egg. A part of this lixivium is to be even diluted, and mixed with an equal weight of oil of olives. The mixture is to be put on a gentle fire, and agitated, that the union may be accelerated. When the mixture begins to unite well, the reſt of the lixivium is to be added to it, and the whole is to be digeſted with a very gentle heat, till the ſoap be completely made. A trial is to be made of it, to examine whether the juſt proportion of oil and alkali has been obſerved. Good ſoap of this kind ought to be firm and very white when cold, not ſubject to become moiſt by expoſure to air, and entirely miſcible with pure water, to which it communicates a milky appearance, but without any drops of oil floating on the ſurface. When the ſoap has not theſe qualities, the combination has not been well made, or the quantity of ſalt or of oil is too great, which faults muſt be corrected.

In ſoft or liquid ſoaps, green or black ſoaps, cheaper oils are employed, as oil of nuts, of hemp, of fiſh, &c. Theſe ſoaps, excepting in conſiſtence, are not eſſentially different from white ſoap.

Any fixed alkalis are much diſpoſed to unite with oils that are not volatile, both vegetable and animal, ſince this union can be made even without heat. The compound reſulting from this union partakes at the ſame time of the properties

of

of oil, and of alkali; but theſe properties are modified and tempered by each other, according to the general rule of combinations. Alkali formed into ſoap has not nearly the ſame acrimony as when it is pure; it is even deprived of almoſt all its cauſticity, and its other ſaline alkaline properties are almoſt entirely aboliſhed. The ſame oil contained in ſoap is leſs combuſtible than when pure, from its union with the alkali, which is an uninflammable body. It is miſcible or even ſoluble in water to a certain degree, by means of the alkali. Soap is entirely ſoluble in ſpirit of wine, and ſtill better in aqua vitæ ſharpened by a little alkaline ſalt, according to an obſervation of Mr. Geoffroy.

When oil unites with alkali in the formation of ſoap, it is little altered in the connexion of its principles, for it may be ſeparated from the alkali by decompoſing ſoap with any acid, and may be obtained nearly in its original ſtate. By the accurate inveſtigation that Mr. Geoffroy has made of ſoap, by decompoſing it thus by means of an acid, he found that two ounces of this compound conſiſt of one ounce three gros and one ſcruple of oil, one gros and a ſcruple of marine alkali deprived of all moiſture, or twice the quantity of this ſalt containing the water of its cryſtallization; and, laſtly, two gros and four grains of water. This latter quantity of water is nevertheleſs variable, according to the condition of the ſoap; for it may be much more or much leſs dry.

Concerning the decompoſition of ſoap by means of acids we muſt obſerve, firſt, that all acids, even the weakeſt vegetable acids, may occaſion this decompoſition, becauſe every one of them has a greater affinity than oil with fixed alkali. Secondly, theſe acids, even when united with any baſis, excepting a fixed alkali, or the inflammable principle, are capable of occaſioning the ſame decompoſition; whence all ammoniacal ſalts, all ſalts with baſis of earth, and all thoſe with metallic baſes, are capable of decompoſing ſoap, in the ſame manner as diſengaged acids are; with this difference, that the oil ſeparated from the fixed alkali, by the acid of theſe ſalts, may unite more or leſs intimately with the ſubſtance which was the baſis of the neutral ſalt employed for the decompoſition.

Soap may alſo be decompoſed by diſtillation, as Lemery has done. When firſt expoſed to fire, it yields a phlegm called by him a ſpirit; which nevertheleſs is neither acid nor alkaline, but ſome water which enters into the compoſition of ſoap. It becomes more and more colored and

and empyreumatic as the fire is encreafed, which fhews that it contains the moft fubtle part of the oil. It feems even to raife along with it, by help of the oil, and action of the fire, a fmall part of the alkali of the foap: for, as the fame chemift obferves, it occafions a precipitate in a folution of corrofive fublimate. After this phlegm, the oil rifes altered, precifely as if it had been diftilled from quicklime, that is, empyreumatic, foluble in fpirit of wine, at firft fufficiently fubtle and afterwards thicker. An alkaline refiduous coal remains in the retort, confifting chiefly of the mineral alkali contained in the foap, and which may be difengaged from the coal by calcination in an open fire, and obtained in its pure ftate.

As all oils contain an acid more or lefs combined, which may alfo be more or lefs difengaged by the oil becoming rancid, by the action of heat, or by combination with other bodies, probably a portion of the alkali of the foap is faturated with the acid of the oil, efpecially after the diftillation of the foap. But this matter has not been fo well examined, that we can affirm any thing concerning it.

Alkaline foaps are very ufeful in many arts and trades, and alfo in chemiftry and medicine. Their principal utility confifts in a deterfive quality that they receive from their alkali, which, although it is in fome meafure faturated with oil, is yet capable of acting upon oily matters, and of rendering them faponaceous and mifcible with water. Hence foap is very ufeful to cleanfe any fubftances from all fat matters with which they happen to be foiled. Soap is therefore daily ufed for the wafhing and whitening of linen, for the cleanfing of woolen-cloths from oil, and for whitening filk, and freeing it from the refinous varnifh with which it is naturally covered. Pure alkaline lixiviums being capable of diffolving oils more effectually than foap, might be employed for the fame purpofes; but when this activity is not mitigated by oil, as it is in foap, they are capable of altering and even of deftroying entirely by their caufticity moft fubftances, efpecially animal matters, as filk, wool, and others: whereas foap cleanfes from oil almoft as effectually as pure alkali, without danger of altering or deftroying, which renders it very ufeful.

Soap furnifhes medicine with a very efficacious and valuable remedy. Till lately, that Mrs. Stephen's lithontriptic remedy has been publifhed, phyficians attended little to the medicinal qualities of foap. They foon found that foap,

ſoap, which is the principal ingredient of this famous remedy, is alſo the only one which has any real efficacy. And although this remedy has been found to be inſufficient to diſſolve moſt ſtones of the bladder, yet experience and obſervation have ſufficiently evinced that it can prevent the enlargement, or even the formation, of ſtones in perſons diſpoſed to that diſeaſe; that it can, in a word, attenuate, divide, and expel the ſtoney particles generated in the urinary paſſages, and which are the firſt materials of the ſtone. And accordingly ſoap is frequently uſed ſucceſsfully in theſe caſes. When ſoap was once diſcovered to act ſenſibly on the glue or binding ſubſtance of that urinary ſand, gravel, and even of ſome ſtones, it was naturally ſuppoſed to be capable of acting more powerfully on other thickened matters, which are too frequent cauſes of many obſtinate diſeaſes. Theſe conſiderations have induced the beſt practitioners to preſcribe ſoap as a reſolving, aperitive, and deobſtruent remedy; and we are certain that it has been employed as ſuch with great ſucceſs.

From the properties of ſoap we may know that it muſt be a very effectual and convenient anti-acid. It abſorbs acids as powerfully as pure alkalis and abſorbent earths, without having the cauſticity of the former, and without oppreſſing the ſtomach by its weight, like the latter.

Laſtly, we may perceive that ſoap muſt be one of the beſt of all antidotes to ſtop quickly, and with the leaſt inconvenience, the bad effects of acid corroſive poiſons, as aqua-fortis, corroſive ſublimate, &c.

SOAP (STARKEY's). This preparation is a combination of fixed vegetable alkali with eſſential oil of turpentine. It is named from the inventor, a chemiſt, called Starkey, who endeavouring to reſolve the problem of the volatiliſation of ſalt of tartar, combined that alkali with ſeveral ſubſtances, and particularly with oil of turpentine, and remarked that from this latter mixture a ſaponaceous compound was formed, which has been ſuppoſed to poſſeſs many medicinal virtues. It enters into the compoſition of pills, named alſo from Starkey. The belief of its good qualities has induced perſons to continue the preparation of this ſoap, and to endeavour, but without ſucceſs, to improve the proceſs.

Although fixed alkalis are not abſolutely inactive upon eſſential oils, they cannot however unite as eaſily with theſe, as with ſweet oils, which are not volatile. If we attempt to combine any eſſential oil, and particularly oil of turpentine,

pentine, with liquid fixed alkali, as in the preparation of ordinary ſoap, we ſhall ſoon find that theſe two ſubſtances cannot unite, or only imperfectly, and in long time. Starkey found no other expedient for the preparation of his ſoap than time and patience. His method, which is perhaps the beſt of all, conſiſts in putting dry alkali into a matraſs, and pouring upon it eſſential oil of turpentine to a height equal to the breadth of two or three fingers. In a long time the combination was compleated. In five or ſix months a part of the alkali and oil are thus combined together, and form a ſort of white ſaponaceous compound. This ſoap muſt be ſeparated from the mixture, and more of it will be afterwards formed in the ſame manner.

Shorter methods have been ſearched for the preparation of this ſoap, by ſeveral chemiſts; and amongſt theſe is the illuſtrious Stahl; who conſidering water as part of the combination of every ſoap, and even that it is a medium by which the ſalt and oil are united together, directs, that after having mixed oil of turpentine with very hot alkali, and having ſhook them together, this mixture ſhould be expoſed in a moiſt place, that all the portion of alkali which does not unite with the oil may deliquiate, and be ſeparated from the part of the mixture that is combined; that this alkali ſhould then be dried, and new oil poured upon it, as at firſt; and, laſtly, that this method ſhould be continued till the whole be reduced into ſoap; and thus the operation will, as he affirms, be greatly ſhortened. Nevertheleſs, later chemiſts, not ſatisfied with this method of Stahl, have endeavoured to ſimplify ſtill more this operation. Mr. Rouelle the younger has publiſhed, in the *Journal de Medicine*, that he has diſcovered a more expeditious method than all thoſe hitherto known for the preparation of this ſoap. Mr. Beaumé has alſo publiſhed in the *Gazette de Medicine* a method of making it in a few hours. It conſiſts in triturating, during a long time, alkaline ſalt upon a porphyry, and in adding to this ſalt, during the trituration, oil of turpentine. According to this able chemiſt, the thick reſinous part only of this oil can truly combine with fixed alkali: and this combination is effected only while the more volatile and attenuated part of the oil is diſſipated. For which reaſon, according to him, a very great quantity of oil of turpentine is requiſite for the formation of Starkey's ſoap, which quantity of oil is indeterminate, as, the more volatile and ethereal it is, the more of it is required; and alſo the trituration upon the porphyry, by promoting the evaporation of the ſubtle part of

the oil, accelerates confiderably the operation of Starkey's foap.

Another artift fays, in the *Gazette de Medicine*, that the operation may be much abridged, by adding to the new mixture a certain quantity of this foap ready made; which correfponds with Mr. Beaumé's opinion. Laftly, Mr. Beaumé has found, that the addition of a little turpentine, or of ordinary foap, confiderably abridges the operation; and this alfo confirms his opinion, which feems to be very probable. We do not mean to blame the zeal of thefe chemifts in making fo many attempts to find a method of preparing this foap quickly, but we confefs that the importance of the object does not feem adequate to their trouble. For, in fact, what does it fignify whether this foap, not ufed in the arts, and but little in medicine, be quickly or flowly made? The effential point is not that it be quickly, but well done.

And to fpeak our fentiments freely, this preparation feems to be uncertain and ill-chofen. For, befides that the true foap of Starkey, that is, the intimate combination of ethereal oil of turpentine with fixed alkali, according to the ufual idea of it, is a thing probably impoffible; we believe that we may affirm, that the faponaceous compounds obtained by any method of mixing oil of turpentine with fixed alkali do not long remain in the fame ftate, and by time neceffarily undergo perpetual alterations.

To be fully convinced of this truth, we may compare together not only thefe foaps made by different proceffes, but alfo the fame foap, a longer or fhorter time after it has been made, and we fhall find confiderable differences in their color, fmell, and confiftence. We fhall find that thofe deliquiate, and are partly refolved into liquor by the air, that have been made with a too ethereal oil, which is incapable of faturating well the fixed alkali; that others acquire by time a pitchy, yellowifh, femi-tranfparent and refinous appearance, which contain too large a quantity of thick refiduum of oil of turpentine. Thofe foaps which feem to be the beft made, which contain a proper quantity of oil of turpentine, which are neither too ethereal nor too thick, preferve longer their white color and the confiftence of true foap: But they neverthelefs participate more or lefs of the faults we have mentioned. Laftly, all thefe foaps are liable to contain a confiderable quantity of a fort of neutral falt, formed by the acid of the oil of turpentine, united with a part of the alkali of the foap. This falt

cryftallizes

cryſtallizes upon the ſurface, and even within the ſoap, which in time becomes quite penetrated and ſtuck all over with a ſaline efflorescence. Theſe bad qualities and alterations of Starkey's ſoap cannot be avoided by any method, as they depend on the nature of eſſential oils, which we cannot change. Theſe ſoaps are known to contain a volatile and ſurperficially combined acid, which unfolds itſelf more and more, or which is engaged more intimately with a portion of oil, to which it gives a thicker conſiſtence. We are no leſs certain that the moſt ethereal part of eſſential oils, or their ſpiritus rector, is ſo volatile, that however attentive we may be to preſerve it, it will gradually diſſipate in time: in a word, we know from experience, that all eſſential oils are drying, and are much more ſpontaneouſly alterable than any others; and that theſe ſpontaneous alterations cannot be prevented by the imperfect combination which they are capable of forming with an alkali. On the contrary, this alkali, by abſorbing their acid, and by facilitating the diſſipation of their ethereal part, with which the alkali is not capable of forming a true union, can only haſten the alterations to which the oil is naturally diſpoſed.

From all this we ought to conclude, that Starkey's ſoap is a difficult, uncertain, variable preparation, which is continually changing its nature, and conſequently its medicinal virtues. This latter inconvenience, although it were the only one, would be ſufficient to make us reject this preparation. And therefore, as is probable, a ſaponaceous ſubſtance, partaking of the properties of fixed alkali and of an eſſential oil, would be uſeful in medicine; ordinary ſoap, incorporated extemporaneouſly with any quantity of eſſential oil which ſhall be judged proper, might be ſubſtituted inſtead of Starkey's ſoap. *See* OILS (ESSENTIAL).

SOAP-ROCK. *or* SOAP-STONE. *See* STEATITES,

SODA. (r)

SOLUTION. Solution conſiſts in an union formed by the integrant parts of one body with the integrant parts of another body of a different nature; and as a new compound is the reſult of this union, we hence ſee that ſolution is nothing elſe than the act of combination.

(r) *Soda* is a name given to the maritime plant *kali,* from the aſhes of which a conſiderable quantity of mineral alkali may be obtained; and alſo to the aſhes themſelves, or to an impure alkaline ſalt extracted from theſe. *See* KALI *and* ALKALI (MINERAL).

As the integrant parts of one body cannot unite with those of another, while they adhere together; therefore solution cannot be made till the aggregation of one of the two bodies at least is broken. And as bodies whose aggregation is broken are necessarily in a state of fluidity or of vapors, an axiom has been formed, *Corpora non agunt nisi sint fluida*, or, Bodies do not act unless they be fluid.

The two bodies which unite in solution are usually distinguished by two different names. That body is generally called the *solvent* which by its fluidity or acrimony appears to be active; and the body which from its want of taste or from its solidity appears to be altogether passive, is said to be *dissolved*. Thus, for example, when metal or marble is dissolved in aqua-fortis, these solid bodies are considered as being *dissolved*, and aqua-fortis as the *solvent*. But these expressions ought not to be taken literally, for they would give a very false idea of what really happens in solution. On the contrary, we are certain that any two bodies, which unite together in solution, reciprocally exercise their action one upon another, and that the union which results from it is only the effect of the mutual tendency which they have to each other: that thus, in the examples mentioned, the marble and metal act as much upon the nitrous acid as this does upon them; and that, if they differ in this respect, that body, whose specific gravity is greatest, acts most strongly. Mr. Gellert, considering the thing in this point of view, affects to represent as *solvents* the bodies which are generally considered as *dissolved*, and says, for instance, that *sand dissolves alkali*. Provided that we understand that the action of the combining bodies is mutual, it signifies little that we name the one *solvent*, and the other the body *dissolved*: and even as the word *solution*, taken in its most proper signification, expresses the separation of the integrant parts of a body, we seem to speak more clearly and accurately when we call that body the *solvent*, whose integrant parts are already separated before the solution, and that the *body dissolved* whose integrant parts are only disunited during the act of solution.

As the solution cannot be effected unless one of the two bodies at least be fluid, and as solid bodies only become fluid by the interposition of the parts of some other fluid, such as water and watery liquors, or fire, hence the solution may be made either by the *humid* or by the *dry way*. The solutions in which the integrant parts of one of the two

two bodies, or of both, are diſtributed in an aqueous fluid, as, for inſtance, thoſe of acids, are *ſolutions by the humid way*; and thoſe ſolutions in which one or both bodies are rendered fluid by fire, as in vitrification, and in allays of metals with each other, are *ſolutions in the dry way.*

The ſolution of bodies is not perfect, unleſs each of the integrant parts of one body are united to one of the integrant parts of another. Hence if one of the two bodies be tranſparent, we ought to have, after the mutual ſolution, a tranſparent compound, as happens in the ſolutions of calcareous ſtones and acids, and of thoſe of earths by alkalis. As therefore the ſolution of ſoap in water is always a little opake and milky, it ought not to be conſidered as complete. The ſame may be ſaid of glaſſes that are not perfectly tranſparent. Their want of tranſparency always proceeds from the parts of the ſand or flint not having been ſufficiently diſſolved by the ſalt, or from their containing ſome refractory matters, ſuch as certain metallic calxes, particularly calx of tin, which reſiſt the action of ſalts.

As the ſolution of two bodies by one another can only be effected by the attraction or tendency which their integrant parts have to each other, hence, after the ſolution, theſe parts are found to adhere together: hence alſo heavy bodies may be ſuſpended in the thinneſt and lighteſt liquids, when they are truly diſſolved by each other. For inſtance, corroſive ſublimate, which is very heavy, may be ſuſpended by ſpirit of wine, which keeps it diſſolved, although this liquor be very light. *See* COMPOSITION *and* COMBINATION.

SOOT. Soot is a collection of ſubſtances formed by the matter of the flame of inflammable bodies, but which have eſcaped combuſtion, from not having ſufficient contact with the air. This matter, which fixes itſelf to the internal ſurface of chimneys, is always of a black color, more or leſs browniſh. This color it receives from an oil that is burnt, and half reduced to the ſtate of coal.

As all inflammable bodies undergo a total decompoſition during their inflammation, all the volatile principles which they contain, and even a part of the fixed principles, by means of thoſe which are volatile, are raiſed in vapors, ſome part of which burns with flame, is totally diſſipated and deſtroyed, and another part is ſublimed and adheres to the firſt cold bodies which it meets.

Soot is, as we have now obſerved, the portion of flame which is reduced to black ſmoke, and which has not been

inflamed from want of ſufficient contact with air. For if the vapors exhaling from an inflammable body ſtrongly heated were ſo rarefied, that each of their parts ſhould be altogether ſurrounded by air, they would all burn with flame, and then we ſhould have no ſmoke or ſoot, or at leaſt this ſoot would not be black, and would contain nothing inflammable. For which reaſon, the greater quantity of air is admitted amongſt bodies which burn with flame, the leſs ſmoke and ſoot we have; and alſo, the ſoot proceeding even from bodies of the ſame kind muſt be very different according to the manner in which they are burnt. In general, we can ſay nothing that will be conſtantly applicable to the nature and principles of ſoot, as its differences ariſe not only from the cauſes above-mentioned, but alſo from the nature of the inflammable ſubſtances which produce it. Thus vegetables, from which little or no volatile alkali is obtained, muſt furniſh a ſoot different from that of animal matters; and the ſoot of a pure oil muſt be different from that of a plant containing all its principles. But theſe differences have not yet been obſerved, becauſe chemiſts have not attended to this ſubject.

We know only that the ordinary ſoot of chimneys has an acrid, bitter, empyreumatic, and diſagreeable taſte; that water can extract from it a duſky-colored matter, which ſhews that it contains ſaline, oily, ſaponaceous parts; that it is capable of being again burnt very vividly and with much flame, as when chimneys are ſet on fire.

If this ſoot be diſtilled in a retort, we obtain from it phlegm, volatile alkali, partly concrete and partly liquid, a black empyreumatic oil, and in the retort much coal remains, from which fixed alkali may be extracted by incineration and lixiviation. Some acid alſo may poſſibly be obtainable from certain ſoots; and generally towards the end of the diſtillation, when the heat is ſtrong, a little ſal ammoniac is ſublimed.

As every ſoot, even that which proceeds from vegetable matters, contains a good deal of volatile alkali, we may infer, that the principles of vegetables ſuffer, by combuſtion in an open fire, changes ſimilar to thoſe occaſioned by putrefaction. Beſides, the quantity of fixed coal which remains after the diſtillation of ſoot, and which furniſhes a fixed alkali, together with much earth, by incineration, ſhows that a very conſiderable quantity of the fixed principles of inflammable bodies is carried off, and even raiſed to a great height, by means of their combuſtion with flame: but,

but, as we have ſaid, ſoots are very different; and the matter is but little known, and requires further reſearches.

SORREL. *(s)*

SPAR. Naturaliſts and chemiſts have given this name to certain cryſtallized ſtones, more or leſs tranſparent, which generally do not ſtrike fire with ſteel, and which are found plentifully within the earth, but more eſpecially in mines of metals.

Under this general name many ſtones are comprehended; becauſe they have the general properties we have mentioned, and becauſe they reſemble each other by the form of their cryſtallization, in which we always perceive ſhining plates, like mirrors; but ſome of theſe ſtones are very different from others.

Some ſpars are entirely ſoluble with efferveſcence in acids, forming ſelenites with vitriolic acid, deliqueſcent ſalts with nitrous and marine acids, and convertible into quicklime by calcination. Theſe ſtones are juſtly called *calcareous ſpars*.

Others, although entirely ſimilar to theſe in appearance, do not efferveſce with acids, are calcinable as gypſum and ſelenites are, and are, in fact, true ſelenites compoſed of vitriolic acid and calcareous earths. Theſe ſpars are eſſentially different from the former, and are *gypſeous* or *ſelenitic ſpars*.

Other ſpars are neither calcareous nor ſelenetic, do not loſe their tranſparency in the fire, and ſeem to be of the nature of *talc*.

Laſtly, a kind of ſtone, cryſtallized in mirror-like plates like a true ſpar, is almoſt opake, is indiſſoluble by acids, and is ſo much harder than all other ſpars as to be capable of ſtriking fire with ſteel. This ſtone is fuſible without addition, by the action of a violent fire, into a ſemi-tranſparent white matter. This ſeems to be the kind that Mr. Wallerius, Mr. Pott, and other German authors, call *fuſible ſpars*. They alſo mention another ſpar which is compact, breaks like glaſs, and melts without addition.

(s) SORREL. The leaves of this plant contain an acid ſalt which may be obtained from the expreſſed juice by cryſtallization. From twenty pounds of freſh ſorrel-leaves Neuman expreſſed ſix pounds of juice, from which two ounces, two drams and one ſcruple of cryſtallized ſalt, together with two ounces and ſix drams of an impure ſaline maſs, were obtained. *See* SALT (ESSENTIAL) *of* SORREL.

From the defcriptions given by moft authors we cannot eafily difcover what they mean by fufible fpar, and by *quartz-fpar*. Thefe matters have not yet been fufficiently examined.

From the properties of all the fubftances called fpars we may conjecture, that they are ftones of all kinds, very different from each other, which being formed in metallic grounds, have contracted, either by the mixture of fome metallic earths, or even by a metallifation begun in their own earth, fome properties common to all, or, at leaft, to the greateft number.

Thefe properties are, 1. A certain form of fhining laminæ in their cryftallization, which appears even in thofe, the figure of whofe cryftals feems leaft difpofed to receive this form, as in thofe which are ftriated; for fparry laminæ are diftinguifhable at the extremities of the ftriæ, or bundles of ftriæ, of which thefe fpars are compofed.

2. A greater fpecific gravity than of all other ftones. Some fpars, efpecially thofe called *heavy fpars*, are fo very heavy, that they come near in this refpect to metals.

3. A greater fufibility than of other ftones; for, befides thofe fpars which are fufible without addition, the mixture of fpars facilitates the fufion of moft other earths and ftones, and they are accordingly ufed as fluxes in the fmelting of moft metallic ores. Probably for this reafon thefe ftones have been called *fluors* by many mineralogifts and metallurgifts.

Laftly, many fpars are found colored by metallic principles, and imitate the colors of the feveral precious ftones, though they are lefs beautiful and vivid.

We fhall not enter into a more particular detail concerning fpars, becaufe what is further known about them rather belongs to natural hiftory, than to chemiftry; befides that our knowledge of fpars is not very diftinct. (*t*)

SPELTER.

(*t*) SPARS. This name is given to many ftones of different properties and appearances, which do not poffefs conftantly any one common character or mark by which they may be certainly diftinguifhed from other ftones. In general, we may obferve, that they are moft frequently found in mines, and that they generally confift of fmooth and fhining plates or laminæ; that fome are tranfparent, and others opake; that fome are colorlefs, and others are colored; that they are cryftallized in various determinate figures, or poffefs no determinate fhape; and, laftly, that they differ fo much in hardnefs, denfity, degree of fufibility, and

...TER. Zinc is ſometimes ſo called. *See*

SPERMA-

...ir moſt eſſential chemical properties, that they cannot ...red as forming a diſtinct claſs of foſſil ſubſtances. We ...wonder, therefore, that authors, eſpecially thoſe who ...een much accuſtomed to the examination of foſſil bo... ...d have given very confuſed and indiſtinct deſcriptions ...Many of them have not been ſufficiently examined; but ...which we have acquired ſome knowledge, we ſhall en... ...diſtinguiſh into their ſeveral different kinds.

...eral ſtones to which the name of ſpar has been given are, ...*ous*, the *gypſeous*, the *fluors*, and *felt ſpar*.

...*areous ſpars* are ſoft, heavy ſtones, which have the com... ...ical properties of calcareous earth. Their texture is ... Some of them have no determinate figure, and ...n their form are called *rhomboidal*. Some ſpars, called ...*-ſpar*, have a pyramidal figure; but when theſe are ...heir fragments ſhow that they alſo conſiſt of rhomboidal ...

...omboidal ſpars are tranſparent, others are opake; ſome ...eſs, and others are colored; laſtly, ſome of them have ... property of refracting doubly the rays of light which ...gh them, and thereby of repreſenting any object; as, ...ce, the letters of a book, ſeen through it, double. ... has been called *iſland cryſtal*, or *refracting ſpar*. Its ...hat of an oblique parallelopiped, contained within ſix ...ram ſides and eight ſolid angles. Each of the obtuſe ... the parallelograms is 101 degrees and 52 minutes; and ...e acute angles is 78 degrees and 8 minutes. Theſe are ...ſions given by Sir Iſaac Newton of the angles of the ...e refracting ſpar.

...ous ſpars may be diſtinguiſhed from others by efferveſ... ... acids.

...*ſeous or ſelenitic ſpars*. Theſe are gypſeous earth, di... ...yſtallized. The form of the cryſtals is rhomboidal. ...alſo called *ſelenites* and *glacies Mariæ*. Sometimes theſe ...ne other forms. They are very heavy. *See* SELENITES, ...CIES MARIÆ.

...argraaf has ſhewn, that under this claſs are to be com... ...l thoſe white opake ſpars, which by calcination with in... ...e matters are capable of receiving a phoſphoric quality, ... that of the Bolognian ſtone, which he alſo ſhews, is a ...ſpar. *See the article* PHOSPHORIC STONES.

...*rs.* Of the ſpars called Fluors, we have treated under ...e FLUOR.

4. *Fleet-*

SPERMA-CETI. (*u*)

SPIRIT. The name of ſpirit is given in general to all liquors obtained from ſubſtances by diſtillation. Spirits are of three principal kinds, namely, *inflammable ſpirits, acid ſpirits*, and *alkaline ſpirits*.

The claſs of inflammable ſpirits includes the moſt volatile and thinneſt part of eſſential oils; the principle of ſmell, or the *ſpiritus rector* of plants; and *ardent ſpirits*, or the ſpirit obtained from wine, beer, and all liquors which have undergone the *ſpirituous fermentation*.

In the ſecond claſs are all acids obtained by diſtillation of minerals, vegetables, and of animals. Such are, 1. The acids of ſulphur, vitriol, alum, all which are the ſame acid, namely, the vitriolic, and the acids of nitre and of common ſalt. They are called *ſpirit of ſulphur, ſpirit of vitriol, ſpirit of nitre*, &c. without ſpecifying that they are acids. 2. The acids of *vinegar*, and of all liquors which have undergone the *acetous fermentation*, and the acids obtained in the diſtillation of vegetables, and of certain animals, as flies, ants, &c. Theſe ſpirits are commonly called *acid ſpirits*, as the *acid ſpirit of guiacum*, the *acid ſpirit of ants*, &c. becauſe the ſubſtances which furniſh them yield alſo ſpirits that are not acid.

4. *Felt-ſpar, Spatum ſcintillans*. This ſtone differs from all the foregoing, in being ſo hard as to be capable of ſtriking ignited ſparks from ſteel. For which reaſon it is referred by Cronſtedt to the ſiliceous claſs of earths, and is by him called *rhombic quartz*; becauſe the particles of which it conſiſts ſeem to be parallelopipeds, each of which is contained within ſix rhombic or rhomboidal ſides. Its colors are various, white, grey, and red.

Several other foſſil ſubſtances conſiſt of large plates, and are therefore ſaid to have a *ſparry texture*. Such are ſome kinds of talks, of horn-blend, of quartz, of amianthus, and ſome calciform ores of metals.

(*u*) SPERMA-CETI is a white, flaky, unctuous ſubſtance, obtained from the heads of whales. It is altogether ſoluble in oils; but is not capable of being diſſolved by cauſtic alkalis, and of forming ſoaps, as other oily matters may. By diſtillation it may be entirely raiſed, without leaving any reſiduum. From four ounces of ſperma-ceti three ounces and a half of oil, and a drachm and a half of phlegm, were diſtilled. The oil diſtilled is not black, fetid, and empyreumatic, like that of other animal ſubſtances, but clear, yellowiſh, and of the conſiſtence of butter. Sugar does not render ſperma-ceti perfectly miſcible with water: but this may be better done by means of yolks of eggs. *Neuman*.

Laſtly,

in the third clafs are liquid volatile alkalis, ob-
m fal ammoniac, from all vegetable matters which
ergone a complete putrefaction, and from all ani-
ters. They are generally called *fpirits* only,
fpecifying their alkaline quality. Thus we fay,
irit of fal ammoniac, *fpirit of hartfhorn*, &c. As
hefe fubftances, particularly fal ammoniac, contain
cid which may be obtained from them, we ought,
mention this fpirit, to fpecify its acid quality, and
t, for inftance, *acid fpirit of fal ammoniac*.

IT (ARDENT). Ardent fpirit, called alfo
wine, becaufe it can be only obtained from fub-
hich have undergone the vinous fermentation, is a
t, very volatile, very fluid liquor, perfectly white
id, and of a ftrong, penetrating, agreeable tafte
l.

fpirit may be eafily inflamed, without being pre-
eated. Its flame is light, white in the center, blue
es, and not very luminous. It is not accompanied
fmoke or foot. It burns without noife, and with-
uffocating or other vapors.

of wine perfectly pure, for of that I fpeak, burns
with concurrence of free air, without leaving
veftige of coal, or of any faline, earthy or other
.

ugh fpirit of wine be altogether inflammable, it is
lefs mifcible with water without any intermediate
e, and in all proportions, which is a fpecific cha-
f this liquor; for it is the only fubftance of the
own which is poffeffed of thefe properties.

rit of wine be expofed to heat in clofe veffels, it does
me, but is eafily reduced into vapors which pafs in
on. Thefe vapors, when collected, are entirely the
rit of wine as before diftillation, without having re-
ny alteration or decompofition, however frequently
ation may have been repeated.

ker fays, that if fpirit of wine be burnt in a tubu-
ort, to which a large glafs receiver has been adapt-
ill be changed into a very fubtle vapor, which con-
n the receiver, and forms a liquor fimilar to pure

naave affirms, that when the vapor of burning fpirit
is collected by an apparatus of proper veffels, it
ng but very pure water.

The

The following are the principal properties of ſpirit of wine relatively to other ſubſtances.

It ſeems to have no ſenſible action upon earths, or upon metallic matters, nor even upon many neutral ſalts; *(x)* but

(x) The degrees of ſolubility of many neutral ſalts in ſpirit of wine are exactly aſcertained by experiments made by M. Macquer, of which an account is publiſhed in the Memoirs of the Turin Academy. The ſpirit of wine he employed was carefully freed from ſuperabundant phlegm by repeated rectifications, without addition of any intermediate ſubſtance. A phial which contained one Paris ounce of diſtilled water when Reaumur's thermometer was at ſix degrees above the freezing point, contained of this rectified ſpirit ſix gros and fifty-four grains. The ſalts employed in his experiments were previouſly deprived of their water of cryſtallization by a careful drying. He poured into a matraſs, upon each of the ſalts thus prepared, half an ounce of his ſpirit of wine, and ſet the matraſs in a ſand-bath. When the ſpirit began to boil, he filtrated it while it was hot, and left it to cool that he might obſerve the cryſtallizations which took place. He then evaporated the ſpirit and weighed the ſaline reſiduums. He repeated theſe experiments a ſecond time, with this difference, that inſtead of evaporating the ſpirit in which the ſalt had been digeſted, he ſet fire to it in order to examine the phenomena which its flame might exhibit. The principal reſults of his experiments are ſubjoined.

Quantity of	*Salts* ſoluble in 288 grains of Spirit	Peculiar Phenomena of the *Flame*.
o Grains	Vitriolated tartar	None.
4 ——	Nitre	Flame larger, higher, more ardent, yellow and luminous.
5 ——	Salt of Sylvius	Large, ardent, yellow and luminous.
o ——	Glauber's ſalt	Conſiderably red.
15 ——	Cubic nitre	Yellow, luminous, detonating.
o ——	Common ſalt	Larger, more ardent, and reddiſh.
o ——	Vitriolic ammoniac	None.
103 ——	Nitrous ammoniac	Whiter, more luminous.
24 ——	Sal ammoniac	None.
o ——	Selenites	None.
288 ——	Nitre with calcareous baſis	Larger, more luminous, red, and decrepitating.
288 ——	Marine ſalt with calcareous baſis	Like that of the calcareous nitre.
o ——	Vitriol of ſilver	None.

48 ——

acids, alkalis, and many oily substances it exhi-
arkable phenomena.

of wine unites with all acids; and by this union
ty of these is diminished. Accordingly, the acids
nbined with spirit of wine are called *dulcified acids*.
TER *of* RABEL; SPIRIT *of* NITRE, *and* SPIRIT *of*
DULCIFIED).

vhen it is mixed in certain proportions with concen-
cids, and distilled, at least, with most of them, it
eives from them, and produces upon them the fol-
lterations.

of all, some of it passes over dephlegmated as much
be without being essentially altered; afterwards it
t of the water essential to it; consequently the na-
the remaining part is changed, and it is converted
quor, the properties of which shew, that it is as
proximated to the nature of oil as it is removed
at of spirit of wine. This liquor, which is very
l very volatile, is called *ether*, which is, according
we have said, a substance exactly intermediate be-
dent spirit and oil. *See* ETHER.

this, the spirit of wine, or its mixture with acids,
all the characters of oil, or rather becomes a ge-
l.

—	Nitre of silver	
—	Luna cornea	None.
—	Vitriol of mercury	None.
—	Nitre of mercury	None.
—	Corrosive sublimate	Large, yellow, luminous, and decrepitating.
—	Martial vitriol	None.
—	Martial nitre	Red, and decrepitating.
—	Martial marine salt	More white, luminous, and sparkling.
—	Vitriol of copper	None.
—	Cupreous nitre	More white, luminous, and green, much smoke. The salin eresiduum became black and burnt.
—	Cupreous marine salt	Fine green, white and red fulgurations.

acquer accompanies the relation of his experiments with
licious reflections not easily capable of abridgement.

4 grains were an acid matter. This salt could not be dried without
on.

Acids,

Acids on their ſides receive from ſpirit of wine, eſpecially after the formation of ether, all the alterations which they uſually receive from oils with which they have been treated and diſtilled. *See* ETHER.

Very ſtrong and dephlegmated alkalis act ſingularly upon ſpirit of wine, and are even capable of decompoſing it, when aſſiſted by a certain degree of heat. They deprive it, firſt, of all its ſuperabundant water, then of the water it contains as a principle, and, laſtly, they reduce it to the condition of a true oil, without making it paſs, as acids do, through the intermediate ſtate of ether. *See* TINCTURE *of* SALT *of* TARTAR.

Spirit of wine is commonly conſidered as the ſolvent of oils and of oily matters; but properly it is the ſolvent only of one kind of oils. Theſe are the eſſential oils and their concretions, ſuch as balſams and reſins; all which ſpirit of wine can diſſolve. It attacks neither the fat oils nor the oily concretions analogous to them, as wax, butter, fat of animals, nor even certain ſubſtances which ſeem to partake more of the nature of true reſin, as copal and bitumens. *See* OILS *and* RESINS.

When ſpirit of wine keeps an oily matter diſſolved, it may be ſeparated by diſtillation, if the oily matter be not volatile, or by diluting the ſolution with a large quantity of water. This water, with which the ſpirit has a greater affinity than with oil, unites with it, and renders it incapable of keeping the oil diſſolved. Hence the oily matter ſeparates at firſt in very ſmall globules, which are diſperſed through the liquor, and give it the white appearance of an emulſion; and theſe globules afterwards collect, forming more conſiderable maſſes, by which the liquor is rendered very clear.

Theſe properties of ſpirit of wine are advantageouſly applied to extract the eſſential oils and reſins of vegetable matters.

Accordingly, by digeſting in ſpirit of wine aromatic plants, for inſtance, thyme, lavender, roſemary, &c. a ſpirituous liquor is obtained, impregnated with the principle of the ſmell, and with the eſſential oil of the plants. Theſe ſpirituous aromatic waters, made by infuſion, ſerve for ſeveral purpoſes in medicine. They are generally colored by a part of the extractive matter of the vegetables, which the ſpirit of wine alſo diſſolves, or by ſubſtances of different colors which reſide in the reſinous ſubſtance. They have hence been called *tinctures*. *See* TINCTURE.

By

ſtillation is obtained from ſpirituous tinctures a
wine much impregnated with the principle of ſmell,
the thinneſt and moſt volatile part of the eſſential
t free from all extracting or coloring matter;
heſe latter are not ſufficiently volatile to riſe with
wine. This ſpirit of wine is called by the general
matic ſpirituous diſtilled water, or only by the name
added to the name of the plant employed: hence
es of *lavender-water*, *roſemary-water*, &c. Waters
made of ſeveral plants, and are diſtinguiſhed by
r names, as *vulnerary-water*, *imperial-water*, &c.
aters are intended for medicine and for the toilette.
find the details of theſe preparations in books on
y, and particularly in *Mr. Beaumé*'s *Elements of*
y.

a tincture has been diſtilled, we may find at the
f the veſſel the reſinous and extractive part which
t of wine had diſſolved. Theſe ſubſtances have
ne ſcarcely any alteration, becauſe they have been
only to a very mild heat. Theſe are extracts of
ade by ſpirit of wine. *See* EXTRACT.

ead of ſubjecting to diſtillation the ſpirituous tinc-
vegetables, they be diluted with a large quantity
, the reſinous part may be very well obtained pure
rate from the extractive part. This latter part
ually ſoluble in water as in ſpirit, remains diſſolved
anding the addition of water, while the former
arates, as we have ſaid, and forms a reſinous

s method are obtained the reſins of jalap, of ſcam-
f guiacum, and of many other vegetable matters;
e reſins, not having undergone the action of fire,
ltered, but remain in the ſame ſtate in which they
the vegetables.

of wine diſſolves alſo very well certain ſalts, as ſal
c, corroſive ſublimate, ſedative ſalt, and perhaps
hers which we do not know of; becauſe this
as not been much examined: but this ſpirit has
no action upon other ſalts, as common ſalt, Glau-
, nitre, concrete volatile alkali, &c. It does not
natters purely gummy and gelatinous, or, at leaſt,
es but a ſmall quantity of them; and as all theſe
re very ſoluble in water, and as water has a ſtronger
ith ſpirit of wine than it has with theſe matters,
s ſpirit may be employed to ſeparate theſe matters
from

ſrom water. For this purpoſe we need only to add a good deal of the ſpirit of wine to the water, which keeps them diſſolved: the ſpirit then ſeizes the water, and obliges the gummy, gelatinous, and ſaline parts which it contained in ſolution to ſeparate from it. The reverſe of all this paſſes in the ſeparation of oily and reſinous ſubſtances from ſpirit of wine by means of water. Spirit of wine coagulates the whites of eggs and animal lymph, by ſeizing upon the water which they contain.

The ſame may be ſaid of the coagulum formed by mixing ſpirit of wine with concrete volatile alkali, diſſolved by the ſmalleſt poſſible quantity of water. This coagulum, which is formed ſuddenly upon the mixture of theſe two liquors, and which is known in chemiſtry by the name *Offa Helmontii* is nothing elſe than a ſudden cryſtallization of volatile alkali, occaſioned by the addition of ſpirit of wine, which ſeizes the water in which that alkali was diſſolved. The ſame may be ſaid of the cryſtallization of all ſalts, which may be inſtantaneouſly effected by the means of ſpirit of wine. *See* CRYSTALLIZATION.

From what has been ſaid concerning the diſſolving power of ſpirit of wine, we may judge of its great utility in chemiſtry in extractions and ſeparations. It is particularly very uſeful in the analyſis of vegetables and animals by menſtruums. By reflecting attentively on the properties of this ſolvent, many analyſes and ſeparations which tend to the progreſs and perfection of chemiſtry may be improved.

We ſhall finiſh this article with ſome reflexions on the nature of ſpirit of wine.

Stahl and moſt chemiſts believe, that ſpirit of wine is compoſed of a very attenuated and very light oil, intimately united by means of an acid with a larger quantity of water than that which enters as a principle in the combination of oil.

Juncker, on the contrary, appears to admit no other inflammable matter in ſpirit of wine than phlogiſton united with the aqueous principle by means of an acid.

Laſtly, Mr. Cartheuſer poſitively advances, that ſpirit of wine is compoſed of pure phlogiſton, not in an oily ſtate, but immediately united with the watery principle alone.

This diverſity of opinion amongſt the ableſt chemiſts proves, that the true principles of ſpirit of wine are not yet perfectly known. This proceeds from the difficulty of

ofing it without an intermediate fubftance, and everal phenomena, fome of which feem to fhew, not a true oil that enters as a principle into fition of fpirit of wine, but phlogifton alone; rs feem to indicate the prefence of a true oil the pureft fpirit of wine.

nix the beft rectified fpirit of wine with water, llow it to evaporate flowly in open air, we fhall he furface of the water a certain quantity of oil; ve feen above, that a true oil may be obtained of wine by treating it with acids.

in, if we attend to the effential and fundamental of fpirit of wine, to its perfect mifcibility with its flame, which is not accompanied with any oke, to the impoffibility of reducing it without the ftate of coal; laftly, to this property, it is inflamed we obtain nothing from it but a ich burns, and pure water; all which properties able to an oil properly fo called; we muft acknow- t not oil, but pure phlogifton, is the inflammable of fpirit of wine. We have reafon to believe, oil which is feparated from fpirit of wine by xtraneous to it, and is only contained in fpirit becaufe the means employed to purify this fpirit cient to deprive it of all oily matter; and alfo, il obtained from mixtures of fpirit of wine with evidently an artificial oil, and produced in the as we may fee at the word ETHER.

it of wine contains a pure phlogifton very much and almoft difengaged, it acts upon the nervous e all the fubftances which contain a very volatile ttenuated inflammable principle. *See* WINE *and* ON. It is alfo very powerfully antifeptic: hence fuccefsfully employed to preferve from putrefac- ers fufceptible of it. It is ufed topically in gan- nd alfo for the prefervation of dead animals, or nimals. *(y)*

See

Reaumur difcovered, that a mixture of fpirit of wine acquired a fpecific gravity greater than would arith- efult from the proportions employed of each of thefe Thus 50 meafures of fpirit of wine and 50 meafures of ed together, were found to make only 98 meafures. t progreffion the denfity is encreafed by mixing various

. L pro-

See for the rectification and purification of spirit of wine, RECTIFICATION.

proportions of the two liquors, had not been determined till M. *Brisson* made a set of experiments with that view; an account of which is given in the Memoirs of the Academy of Sciences of Paris for the year 1769. From his experiments he has constructed the following Table, which shews this progression, and also enables us to discover the proportion of spirit of wine and water, in any given mixture of these (as brandies, rums, &c.) the specific gravity of which is found to correspond with any of the specific gravities in the Table. Thus, for instance, if we find upon accurate trial, that the specific gravity of the rum, brandy, or other mixture, whose strength is required to be known, be to that of water as 942½ to 1000, we learn by inspection of the Table, that this spirituous mixture consists of equal parts of water and spirit of wine, of which spirit the strength is such, that its density is to that of the water as 837 to 1000. The 1st column shews the proportion of well rectified spirit of wine in the mixture; the 2d column shews the proportion of the water in the mixture; the 3d column shews the specific gravity of the mixture; the fourth column shews the difference between the specific gravity of the mixture and that of the preceding mixture; and the 5th column shews the proportion which the several augmentations of density, caused by penetration of the two liquors, have to each other, that is, their progression.

Spirit of Wine.	Water.	Specific gravity.	Differences.	Proportional augmentations of density from penetration.
16 parts	0 parts	837	0	0
15 ——	1 ——	$852\frac{1}{2}$	$15\frac{1}{2}$	$4\frac{51}{128}$
14 ——	2 ——	$867\frac{1}{3}$	$14\frac{5}{6}$	$8\frac{22}{128}$
13 ——	3 ——	$881\frac{1}{3}$	14	$11\frac{41}{128}$
12 ——	4 ——	$894\frac{1}{2}$	$13\frac{1}{6}$	$13\frac{108}{128}$
11 ——	5 ——	$907\frac{1}{3}$	$12\frac{5}{6}$	$15\frac{127}{128}$
10 ——	6 ——	$919\frac{2}{3}$	$12\frac{1}{3}$	$17\frac{98}{128}$
9 ——	7 ——	$931\frac{2}{3}$	12	$19\frac{21}{128}$
8 ——	8 ——	$942\frac{1}{2}$	$10\frac{5}{6}$	$19\frac{104}{128}$
7 ——	9 ——	$951\frac{2}{3}$	$9\frac{1}{6}$	$18\frac{123}{128}$
6 ——	10 ——	$959\frac{2}{3}$	8	$17\frac{14}{128}$
5 ——	11 ——	$967\frac{1}{4}$	$7\frac{7}{12}$	$15\frac{1}{128}$
4 ——	12 ——	$973\frac{1}{6}$	$5\frac{11}{12}$	$11\frac{63}{128}$
3 ——	13 ——	979	$5\frac{5}{6}$	$7\frac{119}{128}$
2 ——	14 ——	985	6	$4\frac{74}{128}$
1 ——	15 ——	$991\frac{3}{4}$	$6\frac{3}{4}$	$1\frac{93}{128}$
0 ——	16 ——	1000	$8\frac{1}{4}$	0

SPIRIT

T *of* LIBAVIUS. *See* LIQUOR (SMOK-

T *of* NITRE. Spirit of nitre and nitrous o names for the same thing. For its properties, NITROUS). We shall here explain the manner g it, or of decomposing nitre in order to obtain

acid, and several matters containing it, are te substances employed for the separation of id from the fixed alkali with which it is united ecause, in general, the former of these two acids than the latter. In several ways nitrous acid ained by distillation; which, however, are funda- he same, although they vary in some circum- cording to the nature of the intermediate sub- loyed, and the required strength of the nitrous

ost frequent method of distilling spirit of nitre, n great works, is to employ clay as an interme- ance. As this kind of earth contains vitriolic very proper for decomposing nitre.

rts of dry and powdered clay are to be well mixed art of nitre. This mixture is to be put into an are retort, placed in a reverberatory furnace. tort a receiver is to be fitted, which is to be well the distillation is to be promoted by a gradual is very gentle at first, and raised towards the end hat the retort shall be very red-hot.

stillers of aqua-fortis use very few precautions, lingly their spirit is generally weak and impure. e first place, they employ nitre of the first, or at e second boiling, which contains always much salt. Hence the acid which they obtain is mixed nsiderable quantity of spirit of common salt. It ently a kind of aqua-regia.

second place they do not dry well their clay, by ans their acid is weak; although they always keep most watery part which passes first; this they call *ting it*.

the lute which they use for joining their vessels rth formed into a paste with water, a part of which the receiver, especially when they unlute the nd renders the spirit of nitre turbid. But as almost ua-fortis which they make is for purposes in which accuracy is not required as in chemical opera-

 tions,

[illegible] which are condense[illegible] there, [illegible] spirit of nitre distill[illegible] gradually by drops. The distillation is to be continue[illegible] till the retort is red-hot, and no more vapor is raised.

Whe

e veſſels are cooled, they are cautiouſly to be
d the liquor in the balloon is to be quickly
a clean and dry glaſs bottle, through a glaſs
ich bottle ought to be quickly ſtopped with a
e. This is the method of diſtilling ſmoking
tre uſed by Mr. Beaumé; and it is a very good
ſmall earthen diſh filled with ſand, on which
of the retort reſts, is very uſeful to prevent the
and too unequal application of heat, which
it certainly liable to be broken. The fat lute
linſeed oil is not capable of being injured by
ſtops very cloſely. But as it remains always
ires to be held by the linen ſoaked in lute of lime
of eggs.

rs of this ſmoking ſpirit of nitre are very elaſtic,
ly condenſible; for which reaſon the diſtillation
owly conducted, and muſt be avoided in hot
A brick wall muſt be interpoſed betwixt the
the balloon to prevent this veſſel from being
heated; the balloon muſt be covered with wet
uently renewed, and even the ſmall hole of the
ſt be ſometimes unſtopped to give vent to the too
too copious vapors; otherwiſe the whole appa-
l burſt with exploſion.

e perceive that the drops ſucceed each other
d that by unſtopping the ſmall hole, red vapors
e length of a foot or more with a hiſſing noiſe;
n that the veſſels are ready to burſt. The heat
be leſſened, and the ſmall hole muſt be very
unſtopped, till the diſtillation be much mo-

when we pour the nitrous acid into the bottle,
be very careful not to ſtand in the way of a cur-
r, becauſe the vapors are very corroſive and
For the ſame reaſon alſo, the mouth of the
ght to be ſtopped as ſoon as the liquor is poured
for the fumes continue in it more than twelve

T (GLAUBER's SMOKING) *of* NI-
Glauber was the firſt chemiſt who thought of
itrous and marine acids by means of pure vitrio-
By this method we may obtain a nitrous acid
centrated; and the proceſs is more eaſy, quick,
ient than the preceding. This diſtillation ought
in the following manner.

 Very

[illegible]

[illegible] Glauber's manner, to render the spirit more smoking.

We may observe, that spirit of nitre obtained by any of these methods is never absolutely pure. It is indeed free from a mixture of marine acid, when the nitre is perfectly purified from that impurity; but we cannot prevent, especially in the distillation in Glauber's manner, some part of the vitriolic acid from rising with it. It must therefore be purified from this acid, when the operations or experiments require a perfectly pure nitrous acid. This purification is easily effected by adding some pure nitre to the acid, and distilling it a second time; by which means the small portion of vitriolic acid mixed with the spirit of nitre is made to unite with the basis of the nitre, and is rendered so fixed that it cannot rise in distillation. We may easily perceive, that for this rectification of the nitrous acid much less heat is required than for the former distillations.

All the residuums of these distillations contain a vitriolated tartar, called *sal de duobus*.

The residuum of the distillation of spirit of nitre by clay contains a vitriolated tartar mixed with a large quantity of earth, and therefore not easily to be extracted. The clay is baked, hardened, and generally very red, because the clays employed for this purpose are ferruginous. This caput mortuum forms a very good cement used for pavements. It is used also, for sake of its color, to make compartments, and

ry the colors of ſandy parterres. It is called the *diſtillers of aqua-fortis.*

iduum of the diſtillation by vitriol contains vitrio-ar, mixed with a pretty large quantity of the rth of this vitriol. Vitriolated tartar may be obtained from it by lotion with water, which is to be filtrated, evaporated, and cryſtalliſed. A nartial earth remains, which is called *colcothar*, *arth of vitriol*, after it has been ſufficiently waſhed. ay remark upon this ſubject, that as the nitrous engaged from its baſis by the acid of vitriol, it urally to be applied to the martial earth of this But as the nitrous acid adheres but weakly to iron, when this metal is calcined and deprived of its , as it is in this operation, the heat that is em- nore than ſufficient to diſengage it, and to make irely in diſtillation.

the reſiduum of the diſtillation of ſpirit of nitre r's manner, when no iron is mixed with it, forms te and very pure vitriolated tartar, which may be filtrated, evaporated, and cryſtalliſed.

ſe reſiduums generally contain alſo a little nitre, having been ſufficiently in contact with vitriolic eſcaped its action, and is not decompoſed.

T (DULCIFIED) *of* NITRE. Dul- t of nitre is a mixture of one part of nitrous acid parts of rectified ſpirit of wine, digeſted to- *z)*

ous acid acts powerfully on ſpirit of wine, it is conſiderably milder by this mixture. It is uſed cinally, and is conſidered as aperitive, and power- etic. It is added by drops to potions and juleps, given an agreeable acidity.

TUS RECTOR. The *ſpiritus rector* is a uated, very ſubtle principle, in which the ſmell riferous bodies peculiarly reſides.

in the ſpiritus rector from odoriferous ſubſtances, ers are to be diſtilled in the cucurbit or body of placed in a water-bath, with a very gentle heat, om thirty to thirty-five degrees of Mr. Reaumur's

London and Edinburgh Diſpenſatories direct that the uld be diſtilled. This operation ought to be perform- very ſlow, and gradually raiſed fire, that exploſions vented.

 ther-

thermometer, till we perceive that what rises in distillation has little or no smell.

The principle of smell in bodies is in general too subtle and too fugacious to be obtained alone and pure, by any method whatever. Accordingly, it rises by means of the water contained in substances distilled in order to procure it, and is dissipated and overwhelmed in water. If the odoriferous matters from which the spiritus rector is required to be procured, were absolutely dry, and contained no other volatile principles, a little water or spirit of wine ought necessarily to be added, to furnish a kind of basis to this spirit, which would otherwise be dissipated and evaporated, so that it could not be collected.

This principle of the smell of bodies is miscible with water, with spirit of wine, and with oils. It seems however to be of different natures, according to the substances which furnish it. Its properties shew that it is in general composed of an inflammable principle, and of a saline substance, both extremely attenuated. But the spiritus rector of some substances appears to be more of a saline, and that of others more of an oily nature.

All matters, the smell of which is quick, pungent, and which do not affect the brain and nervous system, as the acrid, cruciform plants, and substances which undergo the acid fermentation, contain a spiritus rector probably more saline than oily.

Those, on the contrary, whose smell is sweet, nauseous, or strong, without acrimony or pungency, and which affect the head, by curing or occasioning hysterical or convulsive accidents; such are ambergrise, musk, castor, burnt coffee, opium, narcotic plants, camphor, all aromatic plants, and lastly, the substances which undergo the spirituous fermentation; have, according to all appearance, a spiritus rector which partakes of the nature of oil. For besides that the effects produced by these substances are similar to those of the vapor of charcoal, the spiritus rector of some of them is really inflammable; as, for instance, that of fraxinella, the exhalations from which form an atmosphere that may be inflamed with a lighted taper.

The spiritus rector of all aromatic plants seems particularly to be associated with their essential oils; at least, all these oils contain a good deal of it. To this principle they certainly owe their smell, and probably their volatility and thinness; for those which from age, or from not having been preserved in well-closed vessels, have lost their proper smell,

at the ſame time much leſs thin and volatile,
y are no longer capable of being raiſed by the
oiling water; and beſides, the plants from which
is rector has been obtained, furniſh little or no
il. *See* OILS (ESSENTIAL).
iritus rector, even that of aromatic plants, altho'
an oily nature, is perfectly miſcible with water;
n only proceed from its great tenuity, or from
principle which enters its compoſition.
IT *of* SALT. The ſpirit of ſalt, or acid of
ſalt, can only be obtained by means of a ſuffi-
owerful intermediate ſubſtance, to diſengage it
native fixed alkali, which is the baſis of com-
. Vitriolic acid is the moſt proper and moſt
termediate ſubſtance for the diſtillation of ſpirit
It is employed, either engaged in a baſis with
has leſs affinity than with that of common ſalt;
n order to obtain Glauber's ſmoking ſpirit of ſalt.
ry ſpirit of ſalt is diſtilled by the mixture of one
ommon ſalt with two parts of dried clay, pre-
the ſame manner as we have deſcribed for the
n of ſpirit of nitre. *See* SPIRIT *of* NITRE. The
ſalt obtained by this method is white and not
although it may be conſiderably ſtrong, if the
lay have been previouſly well dried.
ay obſerve, that a ſmoking ſpirit of ſalt cannot be
by means of martial vitriol, calcined till it becomes
s practiſed for the ſpirit of nitre. I have tried
his diſtillation; and although a very violent heat
ed, yet very little marine acid was procured. The
n of this difference is, that marine acid diſſolves,
ore eaſily than nitrous acid, metallic earths de-
their phlogiſton, and adheres to them much more
Hence, as ſoon as the marine acid is diſen-
m its baſis by the acid of vitriol, it applies itſelf
artial earth of this vitriol, which retains it with
re ſtrength than it is capable of retaining nitrous

IT (GLAUBER'S SMOKING) *of* SALT.
the ſtrongeſt and moſt ſmoking ſpirit of ſalt, we
ed to employ as an intermediate the pure vitriolic
Glauber has practiſed. But this operation, eſpe-
en we would have ſpirit of ſalt highly concen-
very difficult and laborious, becauſe the vapors
h more difficultly condenſible than any others.
The

The following is the process successfully practised by Mr. Beaumé.

Common salt is put into a tubulated stone-ware or glass retort, which is to be placed in a furnace for distilling; and to this retort a balloon is to be fitted, exactly in the same manner as for the distillation of smoking spirit of nitre. *See* SMOKING SPIRIT *of* NITRE. This apparatus is to be left till the lute has become firm; then through the tubulated opening of the retort, by means of a glass funnel, a quantity of rectified vitriolic acid previously diluted with a little water, equal to a third part of the weight of the salt, is to be poured at several different times, and the opening is to be closed each time immediately after a part of the acid has been added.

As soon as the vitriolic acid is added, we see white vapors passing from the retort into the receiver. These are the smoking spirit of salt which this acid disengages, even without fire; for which reason these first vapors ought to be allowed to pass, before the fire be kindled; which ought not to be done till they are considerably diminished, otherwise the distillation would go on too fast at first, and the vessels might be broken.

A very little fire is to be kept up in the furnace, and only as much as is necessary to continue the distillation. Lastly, the distillation is to be conducted to the end with the same attentions which we directed for smoking spirit of nitre; and when it is finished, the spirit of salt is to be collected in the same manner.

Betwixt this process and that by which a smoking spirit of nitre is obtained in Glauber's manner, two essential differences may be perceived. The first is, that in this distillation the vitriolic acid is not added till the vessels are arranged and luted; and hence a tubulated retort is necessary. The reason of this is, that vitriolic acid disengages the acid of common salt without heat, and as soon as it touches this salt; and that the vapors which pass out copiously from the retort, by keeping the neck constantly wet, render the application of the lute impossible. When the lute happens during the distillation to be deranged, it cannot be again repaired. The shortest method then is to discontinue the operation, and begin again.

The second difference betwixt the distillation of smoking spirit of nitre and smoking spirit of salt by means of vitriolic acid, is, that water is added in the latter distillation, and not in the former. The reason of this is, that the vapors of

entrated marine acid are ſo much more diffi-
ondenſible than thoſe of nitrous acid equally con-
, that if well concentrated vitriolic acid, and
ted common ſalt be employed, almoſt all the
cid would be diſſipated in vapors which would be
ſcarcely a ſenſible quantity of liquor would be
. *See* ACID (MARINE) *for the properties of ſpirit*
nd SALT (COMMON).

eſiduums of the diſtillations of ſpirit of ſalt contain
's ſalt. In that of the diſtillation by means of clay,
is confounded with much earth, and difficultly
le. But the reſiduum of the diſtillation by vitriolic
pure Glauber's ſalt. This ſalt appears a white
aſs at the bottom of the retort. It ought to be
in a crucible, that any remaining acid may be
. It is then to be treated by ſolution, filtration,
tallization.

is diſtillation, Glauber firſt diſcovered the ſalt
he afterwards examined, and called *ſal mirabile*.
ame is ſtill continued; ſo that it is now called *ſal*
ſal mirabile Glauberi, or *Glauber's ſalt*. *See* SALT
UBER.

RIT (DULCIFIED) *of* SALT. Dulcified
ſalt is made by mixing this acid with twice its
of rectified ſpirit of wine, and digeſting this mixture
month.

is acid has much leſs diſpoſition than the vitriolic
ous acids to combine with inflammable matters,
ot be ſo well dulcified as they can by ſpirit of

ors differ much concerning the methods of dulcifi-
The proportions are from two to five or ſix parts of
wine to one part of ſpirit of ſalt. Some authors do not
ether the ſpirit of ſalt ought to be concentrated and
, or not; others require that a ſmoking ſpirit
e employed. Laſtly, ſome direct the diſtillation of
ture, and others are contented with a ſimple di-
But in whatever manner the operation is per-
the acid remains crude, and not much dulcified:
ulcified ſpirit of ſalt is not uſed in medicine; for
es do not eſſentially differ from thoſe of dulcified
nitre, which is infinitely milder.

ne acid, although very concentrated and very ſmok-
es not produce, when mixed with ſpirit of wine,
ery inconſiderable heat and effervеſcence, and much
inferior

inferior to thofe occafioned by vitriolic acid, and ftill more by nitrous acid; which difference proceeds from the little action marine acid has upon the principles of fpirit of wine.

Thefe two fubftances are but little altered by being mixed together: for Mr. Pott having combined a dulcified fpirit of falt with an alkali, obtained a *regenerated fea-falt*, which decrepitated upon hot coals, and precipitated lead and filver from their folutions in nitrous acid into corneous metals. Neverthelefs, we are certain that a part of the marine acid contracts an union, and even an intimate union, with fpirit of wine: for Mr. Pott relates, that having diftilled to drynefs the thick matter remaining after the moft fluid and volatile part of the mixture had been feparated, he found a black, refiduous coal, which cannot be obtained by diftilling any of thefe two matters feparately. *See* ETHER (MARINE).

SPIRIT *of* SULPHUR. Spirit of fulphur is nothing elfe than vitriolic acid obtained from fulphur by burning.

As fulphur cannot furnifh its acid but by burning, and as it cannot burn but in open veffels and free air, we can therefore obtain but a fmall quantity of acid by this method.

Before the acid of fulphur was known to be the fame as ordinary vitriolic acid, a fpirit of fulphur was prepared with great expence and trouble, upon the fuppofition that it had peculiar properties. For this purpofe, fulphur was burnt in an open crucible, placed upon a ftand in an earthen difh filled with hot water. A large capital or glafs-bell was fufpended above this difh. The acid of the burning fulphur meeting the vapor of the hot water, united with this water, and fell down along the fides of the bell, or by the beak of the capital. By this method a very weak acid was procured, which was afterwards concentrated: but at prefent this operation is only performed to fhew, that the acid contained in fulphur is not decompofed during combuftion, and that it is only one and the fame thing with vitriolic acid.

The true method of obtaining much acid of fulphur, is to burn it in clofe veffels by means of a fmall quantity of nitre, as it feems to be practifed in fome places. *See* CLYSSUS. *(a)*

SPIRIT

(a) The greateft part of the vitriolic acid now employed is obtained by burning fulphur. The vapors of burning fulphur are

IT *of* VENUS. This name is given by to the acid of vinegar highly concentrated, ob- distilling verdegrise, or crystals of verdegrise, or s, which are nothing else than combinations of ith acetous acid.

peration by which spirit of Venus is obtained is . Nothing more is required than to put verde- crystals of verdegrise into a retort, one third part ought to remain empty, as is usual: to this retort r is to be adjusted, and the distillation begun with ntle fire: the first portions of liquor which pass e set apart, as they are nothing but phlegm: the n is to be promoted, by gradually augmenting the the retort begins to be red-hot, and nothing rom it.

latile, vitriolic, or sulphureous acid. These are very condensible. For which reason, very large vessels and ne are required in this operation. In great works, sels are used, called *houses*, of a prismatic form, of e altitude is about ten feet, and the base, which is a is six feet long and four feet broad. The bottom of ese vessels is covered with a little water to assist the con- of the vapor. Above the water is placed a small vessel f containing a few pounds of sulphur, to which a small nitre is added; because, by this addition, a larger quan- lphur may be burnt without access of fresh air. The e to be filled with the vapor of hot water, and their sides ith the condensed steam: then the sulphur is to be by touching it with a red-hot iron: the vapor of the sulphur rises slowly; and when it has risen as high as of the great vessel, this must be stopt, or very nearly t the vapor may be confined. The sulphur continues ill the air contained within the vessel and the nitre be capable of maintaining the combustion. The vapor considerable time before it be entirely condensed, not- ing that this condensation is facilitated by the water in , and especially by the steam of water with which the previously filled. When all the vapor of the sulphu- l is at last condensed, the sulphur is to be again kindled, added if it be necessary, and the process repeated as be- hen a sufficient quantity of acid is collected, it is to be of the vessel; and after it has lost its *sulphureous* or vo- lity by exposure to air, it is concentrated and rectified tion. *See* ACID (VITRIOLIC) ACID VOLATILE SUL- s, *and* CONCENTRATION *of* VITRIOLIC ACID.

The

The acid of vinegar passes in this distillation partly in white clouds, and partly in drops. This acid is very strong; because in general acids, which are combined with any body whatever, are by that means deprived of all their superabundant water. Besides, as the acid of vinegar is fixed and retained in a certain degree by copper, it may be easily dephlegmated in the beginning of the distillation.

The spirit of Venus has a very vivid, pungent smell; almost as suffocating as volatile sulphureous acid. The Count de Lauraguais discovered, that if this acid be heated in a wide-mouthed pan, and fire applied to it, it will burn entirely like spirit of wine; and leave no residuum. This experiment, added to the observations made by Becher and Stahl upon the production of vinegar, shew, that spirit of wine enters as a constituent part into the composition of this acid. The Count de Lauraguais also observed, that spirit of Venus well concentrated, easily crystallizes without addition; and this observation has been since confirmed by the Marquis de Courtanvaux. *See* FERMENTATION (ACID), *and* VINEGAR.

As the last portions of the acid of vinegar adhere pretty strongly to the copper in the verdigrise, and to the crystals of Venus; and as we are obliged to give a strong degree of heat to expel them, they then raise along with them a small quantity of this metal, which gives a greenish color to the spirit of Venus: but it is easily freed from these cupreous parts by a second distillation with a very gentle heat; and then it becomes very white.

The acid of vinegar, thus concentrated, has many other properties worthy of attention; amongst others, those of forming ether when distilled with spirit of wine. *See* ETHER (ACETOUS), *and* VINEGAR (RADICAL).

We must observe, that when verdegrise is employed for the preparation of spirit of Venus, we obtain very little of this spirit, and that it is more oily than when it is obtained from crystals of verdegrise, which furnish nearly one half of their weight of the spirit.

After this distillation, we find in the retort the copper which had been the basis of the crystals of verdegrise. This copper is divided into very small parts, which, however, are agglutinated into lumps that are very friable. Its color is blackish, which proceeds from a covering of coal that it has received from the oily matter of the vinegar, which is decomposed towards the end of the distillation. Mr. Beaumé observes, that this coal is easily kindled by the

ation of fire, and burns, like tinder, upon the the copper.

pper, not having loſt any of its phlogiſton, may uſed into an ingot of red copper. We ought only ttle black flux, to prevent or repair the calcina- may be made during its fuſion.

T *of* WINE. *See* SPIRIT (ARDENT).

T *of* VINEGAR. *See* VINEGAR (DISTIL-

T *of* VITRIOL. This name is given to the ns of phlegmatic vitriolic acid which paſs in the of vitriol, or in the concentration of vitriolic e name is given in general to every dilute vitrio-

IT (VOLATILE) *of* SAL AMMONIAC. tile ſpirit of ſal ammoniac is the volatile alkali baſis of ſal ammoniac, and that has been diſen- means of ſome intermediate ſubſtance, which alſo from it ſome of its oily principle, by means of was capable of a ſolid or concrete ſtate; hence is always liquid.

termediate ſubſtances which have the property of this alteration upon volatile alkali are ſtony and alxes. If two parts of quicklime ſlaked in the minium, be mixed together with one part of ſal , and if this mixture be diſtilled, a fluor volatile l be obtained in form of a very quick and pene- irit.

hloſſer, in his Diſſertation on the Fuſible Salt of ys, that the volatile alkali which ſerves as a baſis to horic acid in this ſalt is always fluor, whether it be d by fire alone, or by any intermediate ſubſtance; concrete volatile alkali combined with this acid afterwards be obtained but in a fluor ſtate; which at the phoſphoric acid has the property of taking tile alkali the matter by means of which it is cry- . *See for the properties of volatile ſpirit of ſal am-* LKALI (VOLATILE), *and* AMMONIAC (SAL).

ATITES. *(b)*

STEEL.

EATITES, *Lapis Ollaris*, or *Soap-rock*, is a mineral ſub- a conſiſtence intermediate between ſtones and earths. of its properties it reſembles clays. It is ſoft to the y be formed into a paſte with water, ſufficiently ductile

to

STEEL. Steel, confidered chemically, is nothing elfe than iron reduced by art to a particular ftate, which occafions fome changes in its properties; but thefe properties are effentially the fame as thofe of iron; that is, iron and fteel are not two different metals, but the fame metal in two different ftates: therefore all the fundamental properties of fteel are mentioned under the article Iron. We fhall here only defcribe the method of making fteel, explain the theory of that operation, and mention its differences from thofe of iron.

Stahl, Cramer, and all good chemifts, juftly confider fteel as an improved iron, which is poffeffed of a larger quantity of inflammable principle, fo neceffary to all metals, and which really contains fewer heterogeneous, and more metallic, parts than an equal bulk of iron. We fhall be convinced of this truth by a defcription and explanation of the methods of converting iron into fteel, and by examining the characteriftic properties of fteel.

Steel may be made by fufion or by cementation. The firft method is ufed to convert iron into fteel immediately from the ore. All ores of iron are not ufed indifferently for this purpofe; becaufe fome of thefe, which are therefore called *ores of fteel*, are much fitter than others to furnifh good fteel; and the fteel extracted from them is called *natural fteel*. (c)

The

to be worked on the potter's wheel; and by fire it is hardened fo as to ftrike fire with fteel. It alfo has the property of fuller's earth, in cleanfing cloaths from greafe. But it does not diffufe in water fo well as clays do. And when digefted with vitriolic acid, it does not form alum, as clays do, but a falt fimilar to Epfom falt, hence it contains a large portion of the earth called Magnefia, as M. Margraaf has difcovered. *See* Magnesia. This fubftance is fo foft as to be cut with a knife, or with a tool turned by a lathe. Accordingly it is, in fome places, made into pots for the ufe of the kitchen, and hence is named *Lapis ollaris*. The *Serpentine ftone*, the *nephritic ftone*, the fubftances called *French chalk*, and *Spanifh chalk*, are fo many kinds of Steatites. *See* Serpentine Stone.

(c) Steel is made fometimes directly from the ore, but more frequently from crude or caft-iron. Thefe methods of making fteel are not known in England, but are practifed in Sweden and other parts of Europe. The procefs for making fteel from caft-iron is thus defcribed by Swedenborgius, as it is performed in Dalecarlia.

The

ner method of making steel consists in chusing the
l iron, or that which is most malleable, whether
r cold; and impregnating this iron with a larger

from which the crude iron to be converted into steel
is of a good kind. It is black, friable, and composed
nall grains; and it produces very tough iron. The
into steel is made upon a forge-hearth, something
n common. The sides and bottom are made of cast-
tuyere is placed, with very little inclination, on one
plates. The breadth of the fire-place is 14 inches;
greater. The lower part of the tuyere is 6 ½ inches
ottom. In the interior part of the fire-place, there is
opening for the flowing of the superfluous scoria.
nen first put scoria on the bottom, then charcoal and
charcoal, and upon these the cast-iron run or cut into
. They cover the iron with more charcoal, and excite
When the pieces of iron are of a red-white, and before
to melt, they stop the bellows, and carry the mass
ge hammer, where they break it into pieces of three
nds each. The pieces are again brought to the hearth,
ithin reach of the workman, who plunges some of
he fire, and covers them with coal. The bellows are
w slowly till the iron is liquefied. Then the fire is
and when the fusion has been long enough continued,
are allowed to flow out; and at that time the iron,
The workman adds more of the pieces of crude iron,
treats in the same manner, and so on a third and a
, till he obtains a mass of steel of about a hundred
ich is generally done in about four hours. This mass
d carried to the hammer, where it is forged, and cut
eces, which are further beat into square bars four or
ng. When the steel is thus forged, it is thrown into
it may be easily broken; for it is yet crude and coarse-
The steel is now carried to another hearth similar to
and there broken in pieces. These pieces are laid
n the fire-place, first two parallel, upon which seven
hers are placed across, then a third row across the se-
ch a manner that there is space left between those of
w. The whole is then covered with charcoal, and the
ed. In about half or three quarters of an hour the
made hot enough, and are then taken from the fire,
to the hammer, to be forged into little bars from half
o feet long, and while hot, are thrown into water to
l. Of these pieces 16 or 20 are put together so as to
dle, which is heated and welded, and afterwards forg-
four inches thick, which are then broken into pieces
nt length for use.

portion of inflammable principle, by cementation alone, without fuſion.

To underſtand well theſe methods of making ſteel, we muſt attend to two eſſential properties of iron. The firſt is, that of all metals it is the moſt difficultly fuſible; and that therefore although in the ſmelting of its ores its fuſion be much aſſiſted by the ſulphureous parts of the ore itſelf, yet, as theſe parts are always expelled as much as is poſſible, iron never enters into ſo thin and perfect a fuſion as the other metals.

The ſecond property of iron to which we ought to attend is, that the earth of this metal is capable of combining with the inflammable principle, and of being metalliſed without fuſion.

Theſe things being premiſed, it happens, in conſequence of the former property, that, in the firſt fuſion of ores of iron, we obtain only a hard and brittle iron, both from the ſulphureous parts from which this iron is not entirely diſengaged, and from the preſence of a greater or leſs quantity of earthy matters, which are either unmetallic; or which, if they be ferruginous, have not been metalliſed, from want of immediate contact with the phlogiſton of the fuel.

We may eaſily perceive that theſe earthy parts, unmetallic or not metalliſed, cannot be entirely ſeparated from the perfect iron, becauſe the fuſion is not ſufficiently thin for that purpoſe: but in proportion as the iron is deprived of ſulphur, its fuſion becomes more and more difficult, and we are obliged to have recourſe to another expedient than fuſion to diſengage it from its earthy parts, which in the firſt ſmelting remain intercepted betwixt the metallic parts. This expedient is the forge. The impure iron intended to be rendered malleable is to be heated red-hot, and ſtruck by a very heavy hammer.

This percuſſion, that iron ſoftened by heat ſuſtains, preſſes ſtrongly, and ſolders or welds together the metallic parts, which alone are capable of uniting together; and obliges the unmetallic parts, which are incapable of uniting with the metal, to ſeparate. By this operation theſe unmetallic parts are preſſed between the parts of the iron, and driven by degrees to the ſurface of the metal, from which they are detached in form of duſt and ſcales. This treatment, which is a kind of kneading of the iron, is to be repeated till it has acquired the proper degree of purity and ductility.

The

rations by which ſteel is to be extracted from its
entially the ſame as theſe employed for iron; but
from them in being much more exact; that an
urer, more filled with phlogiſton, and better diſ-
om its earthy parts, may be obtained.
eed in this intention, much ſmaller quantities
uſed at once than when iron is to be extracted
re. Pieces of the firſt fuſion are to be put into
lled and covered with charcoal, and expoſed to a
t excited by ſtrong bellows. Theſe pieces are
fuſed, and kept in fuſion a longer or ſhorter
rding to the nature of the ore; after which they
forged, as iron is, but always in much ſmaller
till they are become perfectly ductile both when
hen cold. Nothing then remains but to temper
f which we ſhall preſently ſpeak.
operations, which are to be ſeveral times repeat-
n that is changed into ſteel muſt evidently be
r purified, and furniſhed with a much greater
inflammable principle, than in the ſmeltings
s of large quantities of iron. As the maſſes of
nall in theſe operations for the procuring of ſteel,
are ſurrounded with a much larger proportion
, the fuſion is not only more complete, by which
ion of the earthy unmetallic parts is much pro-
alſo a greater number of ferruginous parts are
liſed; and as all theſe parts of iron are in more
ntact with the charcoal, which is capable of ſup-
m with inflammable principle, they receive the
ntity of this principle, with which they can

e obſervation may be applied to the operation of
practiſed upon ſmaller maſſes; for the heteroge-
are much more eaſily and copiouſly preſſed out
aſſes than great.
act purification of iron, by which it is converted
muſt evidently be attended with conſiderable loſs,
ion, from the ſeparation of all its heterogeneous
his diminution amounts to nearly one half of the
the iron. This great loſs does not proceed alto-
n the ſeparation of heterogeneous parts; for in
rations uſed for this ſeparation, ſome part of the
lways deſtroyed and burnt, although all poſſible
s are taken to diminiſh this inconvenience, by

 ſecuring

securing the melted or red-hot metal from the contact of external air as much as is possible.

Artificial steel is made without fusion from iron ready forged. The chief point to be attended to in the making of the best artificial steel, is to chuse the iron which is most perfect and most malleable, either when it is hot or cold; which quality always shews that the iron is well purified. It is first to be forged into plates or bars, rather small than large, according to the works for which it is intended; and it is then to be cemented with matters capable of giving to it much inflammable principle. The matters which compose this cement vary according to the uses of different manufactures. They are all good, provided they contain no sulphur, or vitriolic acid, which might form sulphur during the operation; because sulphur, having much affinity with iron, would certainly unite with this metal, would entirely or partly fuse it, and would, by reducing it to a mineral or pyritous state, give to it qualities very different from those which good steel ought to have.

The matters which enter into the composition of the cement for steel, are the coals of animal or vegetable substances mixed with ashes, calcined bones, and other matters of this kind. Mr. Cramer proposes these two following receipts of cements for steel, which appear to be very good.

Take one part of powder of charcoal, half a part of wood-ashes, and mix them very well together: or,

Take two parts of charcoal, moderately pulverised; one part of bones, horns, hair or skins of animals, burnt in close vessels to blackness, and powdered; half a part of wood-ashes, and mix them well together.

When steel is to be made, the bars of iron are to be placed vertically in a cylindrical crucible, which ought to be three inches higher than the bars, and into which a stratum of the cement of about the thickness of a finger has been previously put and pressed down. The bars ought to be about an inch distant from each other, and from the sides of the crucible. The interstices and crucible are then to be filled with cement, so that the bars shall be covered with about the thickness of two inches at least. The crucible, previously covered with a lid which fits it exactly, and which must be carefully luted with clay mixed with sand, is to be placed in a furnace where an equal fire is to be kept; so that the crucible shall be red-hot during eight or ten hour : the iron will then be found to be converted

into

which will be so much better as the iron em-
of a better quality: it then only requires to be
We may observe, that in this operation the
no diminution of weight, and no scoria appear
rface, as Mr. Cramer remarks. By the sole
erefore, of a new quantity of phlogiston, the
s the quality of steel. Thus, if this iron con-
parts of martial earth which was not metallised,
entation they are metallised, and the iron or
ereby improved: but if the iron contained some
tallic parts, they are not separated by this ope-
use the metal has not been fused: and as the
iron which is usually sold, is never so well
m these extraneous matters, as that which is
to steel in the great works for procuring steel
of iron; hence, in general, artificial steel made
ion is not so perfect as that made by fusion.
observe that, in the cementation above de-
iron combines with a part of the phlogiston of
without fusion; which effect proceeds from a
perty of the earth of iron, by which it is capable
g with the inflammable principle, and of being
thout fusion, which is, nevertheless, necessary
tion of all other metallic earths.
which has received only the above-mentioned
differs from iron in its color, which is more
own; in its grain, which is finer and closer;
a greater ductility, flexibility, and softness;
t difference of steel from iron, which renders
ble for many purposes and arts, is the extreme
quires by being tempered.
ation is very simple. It consists in making
, and then in plunging it suddenly in cold
an instant all the qualities of this steel are
his tempering; so that from being very ductile
ecomes so hard and so stiff, that it is no longer
eing cut by the file, but is itself capable of
ercing very hard bodies; that it does not yield
ner, but may be sooner broken in pieces like
be extended. It is sonorous, brittle, very
capable of acquiring the most lively and
l polish, as we see in finely wrought toys of

f this metal is very extensive for numberless
nd necessary utensils of all sorts, of which

without it we should absolutely be deprived: but what renders its use still more general is, that we can diversify at pleasure its hardness and ductility, by varying the temper. The hotter the steel is when tempered, and the colder the water into which it is plunged, the greater hardness it acquires; but, at the same time, it becomes so much more brittle. This very hard temper is necessary for certain tools designed to cut very hard bodies. On the contrary, the less hot the steel is when tempered, and the hotter the water is in which it is tempered, the less hard it becomes, and also the greater ductility it retains; and hence many tools may be made of it fit for cutting bodies moderately hard, which tools are less liable to have their points broken, or their edges notched, than if they were made of a harder steel.

No other general rule can be given for the tempering of steel than that we have mentioned. The proper degree of heat is always relative to the use to which the tools to be made of this steel are to be applied.

Another very convenient property of steel is, that after it has been tempered, it may be again untempered and softened to any degree that we think proper. For which purpose we have only to heat it more or less, and to let it cool slowly. By this method we may soften the hardest-tempered steel.

As the temper is a very essential point with regard to steel, and that the best is in general that which gives the greatest hardness, and destroys the least of the ductility of the metal, various substances are used, into which steel to be tempered is plunged. Such are suet, oil, urine, water impregnated with soot, with sal ammoniac, or with other salts. These particular methods are the bases of many secrets in different manufactures; their advantages cannot be ascertained without a very accurate and continued examination. Very interesting researches remain to be made on this subject.

Steel is usually sold tempered, because, in many manufactures of it, the custom is to temper it as soon as it is made, probably that the purchasers of it may be the better able to judge of its quality. When this steel is to be used, it must be untempered, that it may be extended, filed, and receive the form intended to be given to it; after which each workman tempers it again in his manner. But we also find amongst merchants English steel in small bars, which is not tempered, and which is very good.

Well

Well poliſhed plates of ſteel, put on a gentle fire of charcoal, acquire different colors on their ſurface, and paſs ſucceſſively through ſeveral ſhades, as they become hotter, in the following order; white, yellow, orange, purple, violet, and laſtly, blue, which diſappears and leaves a water-color, if the ſteel has been heated too much or too long. Theſe different ſhades mark the degree of heat or of annealing applied to different tools or utenſils. The moſt generally uſed ſhade is the blue, ſuch as that given to ſteel ſprings.

One of the moſt important properties of ſteel is the magnetic quality which it is capable of acquiring much better than iron. Good mariners compaſſes cannot be made without needles of ſteel.

From what we have ſaid, we may judge that ſteel is much better purified iron than any other iron, impregnated with a larger quantity of inflammable principle, and hardened by the temper. Some celebrated natural philoſophers, but who were not chemiſts, have advanced, that ſteel was only iron which ſtill retained ſomething of its mineral nature, and that its ſtate was intermediate betwixt that of caſt-iron and ſoft forged iron. But this opinion is manifeſtly erroneous. They have been deceived by the hardneſs and brittleneſs of caſt-iron, which are nearly as great as in ſteel. But theſe qualities proceed from a remaining part of the mineraliſing ſubſtances, which leave it a pyritous character, very different from that of true ſteel, ſince this can only be hardened by the temper, and ſince in the preparation of it all ſulphureous matter muſt be carefully avoided. The miſtake of theſe authors proceeded from their ignorance of the inflammable principle, the properties of which have been ſo well explained by the illuſtrious Stahl, and from their being led into an error by the old chemiſts, who perpetually confounded phlogiſton, or the pureſt and ſimpleſt inflammable principle of all bodies, with ſulphur, with ſulphureous matters, and with moſt other inflammable compounds.

Steel may be unmade, or reduced to the ſtate of iron, by a management ſimilar to that by which it is made, that is, by cementation. But the cement uſed for this purpoſe muſt be compoſed of ſubſtances entirely free from inflammable matter, and rather capable of abſorbing it, as calcareous earth and quicklime are. By a cementation then with theſe matters, continued during eight or ten hours, ſteel is reduced to the ſtate of iron.

Stahl considers it as an undecided question, whether steel be more fusible than iron, and says, that the workmen cannot decide it from the violence of fire necessary to melt either of them. He believed with reason, that this question might be decided by melting these metals in the focus of a burning speculum. Mr. Macquer says, that by this method he found steel much more fusible than iron *(d)*. This greater fusibility of steel can be only attributed to the greater quantity of phlogiston united with it, as phlogiston is in general the cause of the fusibility of metals. *(e)*

(d) Soft forged iron can scarcely without addition be brought into perfect fusion by the heat of our furnaces, till the fuel has converted it into steel. But steel is daily melted and cast into ingots, called *cast-steel*, by which it is rendered more uniform and similar in all its parts, and thereby fitter for being wrought into the finer kinds of utensils for which steel is employed. This cast-steel, when again reduced to the state of forged iron by cementation with absorbent earths, is the most uniform, equal, perfect iron which can be obtained.

(e) By conversion of iron into steel, this metal acquires a closer, more compact and finer-grained texture, greater hardness, elasticity, tenacity, density, sonorousness, and disposition to receive the magnetic property; and, as some say, an encrease of weight. It is also rendered less liable to rust by exposure to air; and less liable to emit sparkles when heated. The colors or irises which steel acquires by exposure to heat, and which are marks by which workmen know when any acquired heat is given, are not peculiar to steel and iron, but may also be produced by the same means on all other calcinable metals. These colors proceed from a calcination gradually advancing on that part of the metals which is exposed to air. And as the particles of metals in their different degrees of calcination are probably of different sizes, so they must acquire (according to Sir Isaac Newton's theory, which shews that the colors of bodies depend on the size of their integrant parts) different reflective powers, and exhibit changes of colors.

Steel may be made by fusion from the ore, or by cementation of forged iron with inflammable matters. Anciently, steel is said to have been made by immersing forged iron during some time in melted crude iron. Forged iron may also be changed into steel, as Wallerius affirms, by immersion in melted scoria; or by fusion with black flux, glass-gall, or borax; or by strewing sea-salt upon heated iron, and extinguishing it in dung.

Various opinions are formed concerning the cause of the difference between iron and steel. The most general opinion attributes this difference to the presence of a larger quantity of phlogiston

The affinities and medicinal virtues of ſteel are the ſame as thoſe of iron. *See* IRON.

STONES. This name is given in general, both in chemiſtry and in natural hiſtory, to many bodies of very different natures. But generally hard and compact bodies of an earthy nature are called *ſtones*.

As many different kinds of ſtones as of earths may be diſtinguiſhed. For the parts of every kind of earth being united and agglutinated together, are capable of forming, and actually do form ſtoney bodies. But as this union of

phlogiſton in the latter than in the former. Some authors, attending chiefly to the method of converſion by fuſion, conſider that operation only as a purification of the iron from earthy and heterogeneous particles, and ſteel merely as a more pure and perfect iron. Others, obſerving ſome ſimilitude in the texture of ſteel to certain kinds of caſt-iron, and the hardneſs of both theſe, without attending to their eſſential differences, have imagined that the ſtate of ſteel was intermediate betwixt that of caſt and that of forged iron. Laſtly, ſome metallurgiſts maintain, that the converſion of iron into ſteel is effected not by abſorption of phlogiſton, but by expulſion of ſulphureous or acid particles. To ſupport this opinion, they obſerve, 1. That ſteel is leſs diſpoſed than iron to ruſt; the cauſe of ruſt being, as they think, an acid contained in iron; 2. That ſteel emits fewer ſparkles under the hammer than iron, which ſparkles are found to be moſt frequent in iron abounding with ſulphur, as in red-ſhort iron; 3. That iron may be converted into ſteel by cementation with alkaline ſalts, capable of attracting the acid and ſulphur; 4. That in the preparation of ſteel by fuſion, the metal is rather expoſed to a diſſipation of its inflammable parts and burnt, than further phlogiſticated; and that this operation is accordingly called by workmen *the burning of ſteel*.

In the preparation of ſteel by fuſion, probably much of the earthy matters contained in the iron may be ſeparated, and any contained acid or ſulphur may be burnt or diſſipated. But the converſion of ſteel into iron by cementation with abſorbent earths, in which operation no acid or ſulphur can be abſorbed by the metal, ſhews that the difference between iron and ſteel does not conſiſt in the preſence of an acid or of ſulphur in the iron, but rather in the preſence of ſome ſubſtance in the ſteel, which the inflammable cementing ſubſtance can give to it, and of which abſorbent earths can deprive it. This ſubſtance has been generally believed to be phlogiſton; by the addition of which the metal acquires a new texture, together with the hardneſs, elaſticity, and other peculiar properties of ſteel.

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the integrant parts of any earth does not really change the nature of this earth; and as it always has the same essential properties, especially when considered chemically; we refer to the word EARTH for all that we have to say concerning stones. The origin, and the sensible qualities by which naturalists distinguish different kinds of stones, are treated of in Mr. *Bomare's Dictionary of Natural History.*

Several chemical preparations are also called stones, of which we shall here treat.

STONE (CAUSTIC), *or* COMMON CAUSTIC. *See* CAUSTIC.

STONE *of* BOLOGNA. This stone has been much celebrated for the property it has of becoming phosphoric by calcination. It is a heavy selenitic spar. All spars of that kind, and also several other stones, have the same property. *See* PHOSPHORIC (STONES), *and* SPARS.

STONE (INFERNAL), *or* LUNAR CAUSTIC. *See* CAUSTIC (LUNAR.)

STONE (PHILOSOPHER'S). This name is given by alchemists to the preparation by which metals may be transmuted, gold and silver made, and all the wonders produced of (what they call) the *great work*. *See the articles* METALS *and* METALLISATION.

SUBLIMATION. Sublimation is an operation by which volatile and solid substances are collected and obtained.

This operation is founded on the same principles as distillation, and its rules are the same, as it is nothing but a dry distillation. Therefore all we have said on the article DISTILLATION is applicable here, especially in those cases where sublimation is employed to separate volatile substances from others which are fixed or less volatile.

Sublimation is also used in other cases; for instance, to combine two volatile matters; as in the operation of the sublimates of mercury; or to collect some volatile substances; as *sedative salt*, *sulphur*, and all the preparations called *flowers*.

The apparatus for sublimation is very simple. A matrass or small alembic is generally sufficient for the sublimation of small quantities of matter. But the vessels and the method of managing the fire vary according to the nature of the matters which ought to be sublimed, and according to the form which ought to be given to the sublimate.

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The beauty of ſome ſublimates conſiſts in their being compoſed of very fine, light parts; ſuch as almoſt all thoſe called flowers; as *flowers of ſulphur* and of *benjamin*, *ſedative ſalt*, and others of this kind. When the matters to be ſublimed are at the ſame time volatile, a high cucurbit, to which is adapted a capital, and even ſeveral capitals placed one upon another, are to be employed. The ſublimation is performed in a ſand bath, with only the preciſe degree of heat requiſite to raiſe the ſubſtance which is to be ſublimed; and the capitals are to be guarded as much as is poſſible from heat. The height of the cucurbit and of the capitals is well contrived to accompliſh this intention.

When along with the dry matter which is to be collected in theſe ſublimations, a certain quantity of ſome liquor is raiſed, as happens in the ſublimation of ſedative ſalt, and in the rectification of volatile concrete alkalis, which is a kind of ſublimation, a paſſage and a receiver for theſe liquors muſt be provided. This is conveniently done by uſing the ordinary capital of the alembic, furniſhed with a beak, and a receiver.

Some ſublimates are required to be in as ſolid and compact maſſes as their natures allow. Of this number are camphor, ſal ammoniac, and all the ſublimates of mercury. The propereſt veſſels for theſe ſublimations are bottles or matraſſes, which are to be ſunk more leſs deeply in ſand, according to the volatility and gravity of the matters that are to be ſublimed. In this manner of ſubliming, the ſubſtances having quitted the bottom of the veſſel, adhere to its upper part; and as this part is low and near the fire, they there ſuffer a degree of heat ſufficient to give them a kind of fuſion. The art, therefore, of conducting theſe ſublimations conſiſts in applying ſuch a degree of heat, or in ſo diſpoſing the ſand, (that is, making it cover more or leſs of the matraſs) that the heat in the upper part of the matraſs ſhall be ſufficient to make the ſublimate adhere to the glaſs, and to give it ſuch a degree of fuſion as is neceſſary to render it compact; but at the ſame time, this heat muſt not be ſo great as to force the ſublimate through the neck of the matraſs, and diſſipate it. Theſe conditions are not eaſily attained, eſpecially in great works.

Many ſubſtances may be reduced into flowers and ſublimed, but which require for this purpoſe a very great heat, with the acceſs of free air, and even the contact of coals, and therefore cannot be ſublimed in cloſe veſſels. Such are moſt ſoots or flowers of metals, and even ſome ſaline ſubſtances.

substances. When these sublimates are required, the matters from which they are to be separated must be placed among burning coals in open air, and the flowers are collected in the chimney of the furnace in which the operation is performed. This process is called *sublimation in the manner of Geber*. The *tutty*, *calamine*, or *pompholix*, which are gathered in the tops of furnaces in which ores are smelted, are sublimates of this kind.

SUBLIMATE (CORROSIVE). This preparation, called also *mercury corrosive sublimate*, is a mercurial salt, in which mercury is united with the largest quantity of marine acid with which it is capable of combining intimately.

This salt is called *sublimate*, because it can only be well prepared by sublimation; and it is called *corrosive*, because it is one of the most corrosive salts, or even the most corrosive of all salts with metallic bases.

Corrosive sublimate may be made by several processes, which, however, are all so contrived, that the vapors of mercury and of marine acid shall meet in the same subliming vessel.

The most usual method consists in mixing well nitrous mercurial salt with vitriol of iron and common salt, all well dried; and in promoting the sublimation, as we have said under the article MERCURY.

Another process consists in dissolving mercury in concentrated vitriolic acid, as when turbith mineral is made; in triturating the white saline mass remaining after this solution, previously dried, with an equal weight of dried sea-salt; and in subliming this mixture in a matrass with the heat of a sand-bath, by encreasing the fire till nothing more is sublimed. This process is given by Mr. Boulduc, in the Memoirs of the Academy for the Year 1730. Mr. Spielman observes, in his *Chemical Institutions*, that Kunckel had given it formerly, in a work called *The Chemical Laboratory*.

In this operation, the acid of the vitriolic mercurial salt quits the mercury to unite with the alkali of common salt, to which it has a greater affinity, and with which it forms a Glauber's salt, that remains at the bottom of the matrass after the sublimation; while the marine acid on one side, and the mercury on the other, being both disengaged, are reduced into vapors by the effect of heat, unite strictly together, and form the corrosive sublimate, which attaches itself to the upper part of the matrass. This sublimate

consists

consists partly of a white, semi-transparent, saline mass, and partly of shining crystals, composed of small and pointed plates.

This method of making corrosive sublimate is well-contrived, and seems preferable to the ordinary process; 1. Because the mercury, being previously dissolved by vitriolic acid, is as easily and perfectly mixed with common salt in this as in the ordinary process. 2. Because the acid of the vitriolic mercurial salt disengages powerfully and plentifully the acid of common salt; and that it is necessary, as we shall see, that the mercury should meet all the quantity of marine acid with which it is capable of uniting, to obtain the most corrosive sublimate. 3. The process of Kunckel and Mr. Boulduc is more simple than that with vitriol; the operator is less exposed to the acid vapors, the mixture from which the sublimate is separated is less voluminous, and therefore this method is justly preferred.

We think we ought to observe, upon the subject of this process, that almost all chemists, who have mentioned it since Mr. Boulduc, say, that it is made from a mixture of turbith mineral with common salt. This is an inaccuracy capable of leading readers into a mistake; for the vitriolic mercurial salt, employed by Mr. Boulduc, is very different from *turbith mineral*; it contains a large quantity of concentrated, vitriolic acid, which is very necessary in the operation; whereas turbith mineral contains very little or no vitriolic acid, when it has been well washed, according to Mr. Beaumé's experiments; and consequently, if turbith mineral be employed with common salt, in the proportions directed by Mr. Boulduc, we should obtain no sublimate, or but a very small quantity of a sublimate, which would not be corrosive.

The saline sublimates of mercury may be obtained by several other processes; for instance, the vitriol of the ordinary mixture may be omitted; we might also employ crude mercury instead of the mercurial nitre, and triturate it a long time with vitriol and salt, as Lemery says, or sublime the *white precipitate* alone. But we shall say no more of these methods, because they are all inferior to those we have mentioned, when a very corrosive sublimate is required; although some of them, as the sublimation of white precipitate, be very convenient, and may furnish a sublimate which probably is very good, when it is intended to be afterwards converted into *sweet mercury*, or *mercurial panacea*. But we must mention another method of making

making this ſaline ſublimate of mercury, propoſed alſo by Lemery, becauſe it is founded on a miſtake which ought to be made known.

This method conſiſts in triturating crude mercury with twice its weight of common ſalt; and in ſubliming this mixture, from which, according to Lemery, may be obtained a white ſublimate, leſs corroſive indeed, as he acknowledges, than the ordinary ſublimate, but which, nevertheleſs, is corroſive.

What Lemery ſays upon this ſubject is certainly true; but a modern author infers from thence, that mercury decompoſes common ſalt, that marine alkali has not a ſtronger affinity than mercury with marine acid, and that this experiment contradicts eſtabliſhed affinities. But none of all theſe conſequences is juſtly deducible. We explain this kind of paradox in the following manner.

For this purpoſe we muſt previouſly know, 1. That common ſalt, even when cryſtallized very regularly, is not a pure, homogeneous ſalt; but that it is intimately mixed with another ſalt, compoſed of marine acid, neutralized by a calcareous earth. 2. That the acid of this marine ſalt, with calcareous baſis, eſcapes merely by the action of fire, and without any other intermediate ſubſtance than a little moiſture. 3. That when mercury is ſublimed with ordinary common ſalt, that is, common ſalt which has not been purified from the mixture of this ſalt with calcareous baſis, it combines with the acid of this latter ſalt, and not with that of the true common ſalt, and forms a mercurial ſublimate. The proof of this is, that if, as Mr. Beaumé has done, common ſalt be diſſolved in water, and if into this ſolution ſome of the lixivium of ſoda be poured, till no more earth be precipitated, in which operation the ſalt with earthy baſis is evidently decompoſed, and is changed into a ſalt with baſis of fixed alkali; and if the pure ſalt remaining in the liquor be afterwards cryſtallized, and mixed with mercury, and the ſublimation be attempted, not a particle of ſaline ſublimate of mercury will be obtained. This experiment has been verified moſt ſcrupulouſly by Mr. Beaumé. Mercury ſingly cannot decompoſe common ſalt, therefore none of the conſequences inferred from the inaccurate experiment of Lemery are juſtly deducible. We might draw other conſequences not very favourable to the chemiſt alluded to, but we abſtain from them on account of his perſonal merit, and that we

we may not imitate the harſh and ſatyrical criticiſms which diſhonour his writings.

The ſublimates compoſed of mercury and marine acid, in which the metallic ſubſtance has had an opportunity of combining with all the acid with which it was capable of uniting, are evidently combinations of preciſe and determinate proportions of theſe two ſubſtances. Accordingly corroſive ſublimate, when well made, that is, as corroſive as it can be, being ſublimed a ſecond time with new marine acid, does not unite with a larger quantity of acid, nor become more corroſive. But we do not yet ſeem to have determined preciſely the proportion of marine acid, relatively to that of mercury, in the moſt corroſive ſublimate. According to Lemery, ſixteen ounces of mercury produce nineteen ounces of corroſive ſublimate; and, according to Tachenius, in the great works in Holland, where this preparation is made, 280 pounds of crude mercury furniſh 360 pounds of ſublimate; which would ſeem to prove, that the quantity of marine acid is greater in the ſublimate mentioned by Tachenius, than in that by Lemery. But as more of the mercury may be diſſipated when the quantity operated upon it is but ſmall, than when it is large, we can aſcertain nothing from comparing together the reſults of theſe two authors. However, we ſee that the quantity of mercury is much larger than that of the acid, ſince even in the ſublimate of Tachenius, the quantity of mercury was more than three times the quantity of acid; which deſerves to be remarked, as we ſhall ſee when we mention the principal properties of corroſive ſublimate.

The ſpecific gravity of this mercurial ſalt has not been hitherto determined, but it is evidently very conſiderable. It is very cryſtallizable, either by the uſual method for cryſtallizing ſalts, or by ſublimation, and the form of its cryſtals is the ſame in both caſes. It is not deliqueſcent, is difficultly wetted by water, and, in this reſpect, is ſimilar to arſenic. It is one of the ſalts which are very little ſoluble in water. According to the experiments of Mr. Spielman, an ounce of diſtilled water can diſſolve only thirty grains of it, with the aſſiſtance of a heat of fifty degrees of Fahrenheit's thermometer, which correſponds nearly to the tenth degree above the freezing point of Mr. Reaumur's thermometer; that is, that with this heat water can diſſolve only a nineteenth part of its weight of corroſive ſublimate.

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All these properties of corrosive sublimate are naturall deducible from the large quantity of mercury which enter its composition: it perfectly resembles in this respect a the neutral salts, which contain a matter that is not saline intimately joined to the saline principle. But this circumstance is very remarkable, that corrosive sublimate has a the same time very contrary properties, by which it als resembles those neutral salts in which the acid is but littl connected and imperfectly saturated with their basis. Thes properties are, 1. Its corrosive quality, which renders i one of the most violent and active poisons; and, 2. It capacity of receiving a much larger proportion of mercury which unites intimately with its acid, saturates it entirely and even so completely, that this salt, from being ver corrosive, is rendered, by this new addition of mercury, sweet sublimate, almost insipid, almost unsoluble in water and which has nothing in common with a neutral salt bu external appearance.

These latter properties of corrosive sublimate do not allow us to doubt that marine acid, although already united i this salt with a large quantity of mercury, and even very intimately, is yet very far from being saturated. Accordingly this acid is, at the same time, in two states in som measure contrary. Several of the properties of corrosive sublimate seem to shew that its acid is saturated as com pleatly as the acid of the most perfect neutral salts; whil other properties indicate that it is far from being com pleatly saturated.

To form a just idea of this singular state of marine aci in corrosive sublimate, we must first of all observe, that w should judge very erroneously of the state of the acid of a neutral salt, if we considered the properties of this salt a depending only on its acid. We have elsewhere observed and we shall prove it further in this article, that bodie which are not saline, being united to acids in neutral salts have their peculiar action as well as these acids; and tha the properties of these salts are always the result of th combined properties of their acids and of their bases.

In the second place, we ought to recollect the distinction we have made under the article SATURATION, into *relativ saturation*, and *absolute saturation*, which are two things very different; because, in fact, it happens in many combinations, that a principle is in a relative, perfect saturation with regard to another; that is, that it is united with all the quantity of this second principle which it can dissolv

diſſolve, although it be very far from being in a ſtate of abſolute ſaturation; that is, from having ſo exhauſted all its action upon this ſecond principle, that no more remains to be exerciſed upon any other ſubſtance: For, if this were not ſo, we could not make any decompoſition by an intermediate ſubſtance. Thus in bodies compounded of two principles, ſuch as, for inſtance, neutral ſalts, one of their principles, and not the other, may be relatively ſaturated. Alſo one of the two principles, or both, may be in a perfect, relative ſaturation, although one or both be far from abſolute ſaturation.

Theſe things being premiſed, if we reflect on the properties of corroſive ſublimate, we ſhall eaſily perceive, 1. That the marine acid cannot be united with ſo large a quantity of mercury as it is in this ſalt, without being conſiderably approximated to a ſtate of abſolute ſaturation; hence corroſive ſublimate does not redden blue colors, has no acid taſte, does not attract the moiſture of the air, is very cryſtallizable, and not very ſoluble in water; in a word, that it is nearly in the ſame ſtate as ſeveral neutral ſalts, as vitriolated tartar and others, the acids of which are generally conſidered as being well ſaturated.

Secondly, We ſhall eaſily diſcover alſo, that although the acid of corroſive ſublimate approaches as much to abſolute ſaturation as the above-mentioned properties indicate, it is not nearly in a ſtate of relative ſaturation with regard to the mercury; ſince we know that it is capable of uniting again with a much larger quantity of mercury than is in corroſive ſublimate, as is ſhewn by the transformation of corroſive ſublimate into ſweet mercury; and we ſhall naturally conclude from theſe facts, that marine acid is capable of uniting with ſo large a quantity of mercury, that it cannot be entirely ſaturated with that ſubſtance, without exhauſting almoſt all the action it is capable of, and approaching nearly to the ſtate of abſolute ſaturation. Accordingly we ſee, that the properties of this acid become inſenſible, and are almoſt annihilated in ſweet mercury.

Thirdly, in reaſoning ſtill from principles above-mentioned, and in applying them to corroſive ſublimate, it will evidently appear, that although the acid of this ſalt is not nearly ſaturated with mercury, as we have obſerved, the mercury is nevertheleſs in a ſtate of relative ſaturation with regard to the acid; ſince, according to Mr. Rouelle's experiment, this ſalt cannot by any means receive a larger quantity of acid. But if, on the other ſide, we attend to

the quantity of mercury in corrosive sublimate, it w
appear very probable, that although this mercury be sa
rated with acid as much as it can be, and that in t
respect it be in a state of perfect relative saturation, yet i
very far from having exhausted upon this acid all
tendency it has to combination in general, and from be
in a state of perfect, absolute saturation. In fact, on
side, the aggregation of the mercury is broken in c
rosive sublimate, and consequently all its integrant pa
are capable of exerting their general tendency to combi
tion: but, on the other side, these parts of mercury
united but to a very small quantity of acid, and proba
much of their tendency to union remains therefore unsa
fied; and we may reasonably conjecture, that from t
condition, or state of the mercury in corrosive sublima
proceeds the causticity of that saline matter.

This notion will undoubtedly appear very bold to th
who are accustomed to consider the causticity of sal
matters as an effect only of the concentration and imperf
saturation of their saline principles.

But we repeat it, that we should judge very erroneou
of the properties of any compound body, if we were
attribute them to one of its principles only. On the co
trary, all the phenomena of chemistry shew, that all
constituent parts of any compound contribute more or l
to all the properties of this compound. All the parts
matter are active, by the general tendency which they ha
to mutual combination. Nothing is purely passive in natu
and if certain substances seem to us to be more inactive a
inert, it is because their parts, having exhausted all their te
dency and activity one upon another, by their union, are i
seeming rest, which we call saturation, and do really b
come inactive with regard to many other bodies: but wh
by some cause this union is broken, and its parts beco
disengaged, their essential activity then appears again in all
force; they resume all their tendency to combination, th
are in a violent state, till they find some substance w
which they may unite, and satisfy this tendency. T
violent state, this *nisus*, are the same thing as causticity,
rather this latter quality is an effect of the former qualit
rendered sensible by their exertion upon animated bodi
Accordingly, all matter in nature, however inactive a
passive it may seem, is capable of becoming, by the separ
tion of its primary integrant molecules, an agent or solve
and a very powerful corrosive.

We conceive then, that in corrosive sublimate the aggregation of the mercury being broken, its primary integrant molecules are, on one side, in this violent state, in this tendency to union above-mentioned; and, on the other side, that as this tendency to union is only capable of being satisfied partly, and imperfectly, by the marine acid, much of it remains unsatisfied, which gives a proportionable degree of causticity to these molecules; so that the mercury itself of the corrosive sublimate is corrosive, and probably much more so than even the marine acid.

However strange and singular this opinion may appear, we shall find, by reflecting on the nature of corrosive sublimate, that no other cause of its causticity can be conceived. In fact, we must allow that this salt is much more caustic than pure marine acid. For we are certain that a gros [72 grains] of this acid, or more, diluted in water, might be swallowed without the least inconvenience; whereas half the quantity of corrosive sublimate, diluted in the same, or a much larger quantity of water, would infallibly poison. If then we suppose, that the causticity of this salt is nothing else than the causticity of the marine acid contained in it; how can we conceive that this acid, which, very far from being disengaged, and from possessing all its acidity in corrosive sublimate, is, on the contrary, united with more than thrice its weight of mercury, and is neutralised so as to form a very crystallizable salt, not deliquescent and not very soluble in water, which does not change to red the blue colors of vegetables, and gives no mark of acidity, can be infinitely more corrosive than the same acid when free and disengaged? We might as well say, that vitriolic acid is more corrosive in vitriolated tartar than when pure. The causticity then of corrosive sublimate must be chiefly attributed to the mercury, which is the predominant and least part of that saline substance. The mercury in corrosive sublimate appears to be nearly in a similar state as the earthy principle in fixed alkalis; that is to say, its aggregation is destroyed, at least in great measure, and its quantity is very large in proportion to that of the saline principle. Accordingly, corrosive sublimate, instead of changing the blue colors of vegetables to red, as acids do, changes them to green, as if it were an alkali, according to the observations of Mr. Rouelle; and in the same manner as alkalis seem to owe their causticity to the proportion and peculiar state of their earth, so also does the causticity of corrosive sublimate proceed from the quantity

and diſpoſition of its mercury. This cauſticity, then,
rather of an alkaline than of an acid kind.

An objection might be made here, that if the cauſtic
of corroſive ſublimate depended on the mercury, it ou
to be encreaſed by encreaſing the proportion of the mer
ry; whereas we know, that the addition of more merc
has a contrary effect, as we find from the inſtance of ſw
mercury.

The anſwer to this objection is not difficult. Altho
the cauſticity of corroſive ſublimate depends more on
mercury than on its acid, we cannot doubt that this a
alſo contributes to produce this effect, according to the
neral rule, that all the principles of bodies conduce m
or leſs to their properties: but the acid of ſublimate is
deed nearly in the ſtate of abſolute ſaturation, althoug
is not quite in that ſtate; and however neutraliſed it m
ſeem, it is yet capable of a certain degree of action:
when it is totally ſaturated with mercury, it is then
completely in a ſtate of abſolute ſaturation; becauſe
acid is capable of uniting with ſo much mercury, that w
it is combined with this metallic ſubſtance, its relative
turation and its abſolute ſaturation are almoſt the ſ
thing. We need not then be ſurprized, that in this reſ
the cauſticity of the ſublimate is conſiderably diminiſh
but, beſides, when the quantity of mercury much exc
what ought to be contained in corroſive ſublimate, we
eaſily perceive that the parts of the mercury, being pr
nearer the parts of the acid, are alſo more and more unite
gether, and approach more nearly to the ſtate of aggregat
in which ſtate mercury cannot have any cauſticity. *Se*
the properties, chemical and medicinal, of corroſive ſublimate
articles ACID (MARINE), *and* MERCURY.

SUBLIMATE (SWEET). *See* MERC
(SWEET).

SUBLIMATE (RED). If a ſolution of mer
in nitrous acid be evaporated and dried, and then exp
to a ſtrong heat in a matraſs, the nitrous acid will be ſ
rated from the mercury in great meaſure, and will be
pated in red vapors; the ſaline maſs remaining in
matraſs acquires at firſt a yellow color, which afterw
changes to an orange color, and laſtly to a red. Th
called *red precipitate*. But by expoſing this red matte
greater heat, it is ſublimed, while its color is preſe
It is then called *red ſublimate*. This ſublimate is not

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SUGAR. Sugar is a cryſtallizable eſſential ſalt, of a ſweet agreeable taſte, contained, more or leſs plentifully, in many kinds of vegetables; but in moſt of them in ſo ſmall a quantity, or confounded with ſo much extraneous matter, that it cannot be obtained from them with profit.

The plant which contains and furniſhes moſt of this eſſential ſalt is a kind of reed, which grows in hot climates, called *ſugar-cane*.

The method uſed for the extraction of ſugar from the cane, is the ſame as is employed for the extraction of any eſſential ſalt from the juices of plants, with this difference, that as ſugar and liquors containing it are very fermentable, this ſalt is not obtained by a regular cryſtallization, but by a much ſpeedier coagulation.

After having entirely expreſſed the juice from ſugar-canes, it is boiled in caldrons at different times with lime-water and lixivium of aſhes, both to clarify it, and to evaporate it ſo much, that when it cools, moſt of it coagulates, or confuſedly cryſtallizes. This coagulated matter is to be ſeparated from the remaining liquor, which is called *melaſſes*. From this liquor, by fermentation and diſtillation, an ardent ſpirit is obtained, called *rum*. The ſolid ſubſtance, or ſugar, is mixed with much mucilaginous extractive matter, which renders it ſoft and red. To purify, or, as it is called, to *refine* it further, it muſt be rediſſolved in pure water, and its heterogeneous parts muſt be ſeparated by boiling with quicklime and lixivium of aſhes, to which is added a certain quantity of ox's blood, for a more perfect clarification and purification. Laſtly, the ſugar, when refined, is put into earthen conical veſſels open at both ends, the ſmaller of which is turned downwards. *(ſ)* The ſugar is covered with ſome earth moiſtened with water. This water filtrates through the ſugar, diſſolves the mucilage or ſlime which ſtill adheres to the ſugar, and flows out at the opening in the lower point of the conical veſſel. In this manner is obtained this pleaſant and uſeful ſalt. To whiten and purify it perfectly many clarifications are required, the cauſe of which is chiefly a ſlimy matter, like honey, that adheres to it.

(ſ) The aperture in the lower narrow part of the mould is ſtopt with a plug when the ſyrup is poured into the mould, and when the ſugar is become ſolid, the plug is drawn out, that the mucilaginous or treacly matter may drain.

This eſſential ſalt is ſoluble in water, like all other ſal[ts] and even is one of thoſe ſalts that is ſoluble in the ſmalleſ[t] quantity of water.

It is cryſtallizable; and its cryſtals, when ſlowly and re-gularly formed, are beautiful and tranſparent, called *ſugar-candy*. *(g)* This ſalt conſiſts of an acid united with a larg[e] quantity of a very attenuated and mucilaginous earth, an[d] with a certain quantity of ſweet and not volatile oil, whic[h] is in a ſtate perfectly ſaponaceous, that is, entirely ſolub[le] in water by means of the acid.

Sugar, when diſtilled, yields a phlegm, an oily empyreu-matic acid, a ſmall portion of colored empyreumatic oi[l] and leaves a conſiderable quantity of reſiduous coal.

This ſalt is very ſuſceptible of the ſpirituous fermen-tation, when it is diluted in a ſufficient quantity of water and, like all the other ſubſtances capable of that fermen-tation, it is very nutritive to animals.

The nutritive and fermentative parts of vegetables hav[e] not been ſufficiently examined, to enable us to determine whether they be perfectly of a ſaccharine nature. W[e] know, however, that they furniſh by analyſis the ſam[e] principles, and nearly in the ſame proportion; that the[y] all have a ſweet, agreeable, and generally ſaccharine taſte that every vegetable or animal ſubſtance that is ſaccharin[e] is alſo nutritive and fermentative; and, laſtly, that genuin[e] ſugar may be obtained from moſt of them.

Mr. Margraaf has obtained ſugar from the roots of ſeve-ral plants, as from carrots, parſnips, white and red beet[s]. Some of theſe roots, as, for example, the white beet, fur-niſhed a very conſiderable quantity of ſugar. He obtaine[d] about half an ounce of ſugar from half a pound of the drie[d] root. This able chemiſt, conſidering that ſugar is ſolub[le] in ſpirit of wine, and that the mucilaginous parts of plan[ts] are not ſoluble in that fluid, eaſily obtained a pure ſugar b[y] digeſting the dried roots in that ſpirit, and by evaporatin[g] the liquor. Afterwards, hoping to find a cheaper metho[d]

(g) The cryſtallization of ſugar, or the formation of ſuga[r] candy, requires peculiar management. The ſyrup, boiled dow[n] to a proper conſiſtence, is poured into pans placed in a roo[m] the air of which is rendered very hot; by which means th[e] tranſition of the ſugar from a fluid to a ſolid ſtate is ver[y] ſlowly effected, and the parts of the ſugar are allowed, notwith-ſtanding the viſcidity of the liquor, to arrange themſelves ac-cording to their peculiar form.

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that his discovery might be useful, he attempted successfully to obtain sugar by the ordinary process very little varied. He could not indeed obtain a very pure sugar without repeating very frequently the solutions, clarifications, and other operations, as may be seen in his Memoir, or in the Eighth Dissertation of his *Opuscules Chemiques*. But at last he did succeed; and we have reason to hope, that by improving the process, much sugar may be obtained from other vegetables, as from green peas, cabbage, green farinaceous grains; from several trees, as the sycamore, and the birch trees, some of which have more of a saccharine taste than several of the plants from which Mr. Margraaf extracted sugar. *(h)*

The chief, and perhaps the only difficulty to be surmounted in this extraction of sugar, proceeds from the viscid matters, which are so mixed and blended with the saccharine substance of plants, that they prevent its crystallization. The saccharine and mucilaginous parts might be separated from each other by means of a menstruum, which could dissolve the sugar and not the slimy substance, or which could dissolve the latter and not the former. To discover such a menstruum seems to be the proper object of inquiry for those who would prosecute this subject.

SUGAR *of* LEAD. *See* SALT *of* LEAD.

SUGAR *of* MILK. *See* MILK.

SULPHUR. No word has been so much used by chemists, and at the same time so much abused, as *sulphur*. By this the ancient chemists denoted all inflammable substances, of whatever nature they might be. Sulphur, according to them, is one of the principles of bodies. They spoke continually of the sulphurs of metals, of the sulphurs of plants, of the sulphurs of animals: oils, ardent spirits, resins, bitumens, were all sulphurs. In every thing they

(h) Maize, or *Indian-corn*, while green, contains a liquor from which the American savages are said to extract sugar. Sugar may also be extracted from the *Asclepias caule erecto simplici annuo* (Linnæus Hort. Cliff.), and from many flowers collected while the morning dew is on them. Encyclop. tom. xv. p. 617. & Mem. of the Swedish Acad. tom. xiii. But the vegetable which yields the largest quantity of sugar, next to the sugar-cane, is the kind of maple tree called the *sugar-maple*. The methods employed for the extraction of the sugar from this tree, in Canada, are related by M. Gautier, in the *Mem. des Sçav. Estrang.* tom. 2. and by M. Kalm, in the *Swedish Memoirs* for 1757.

found a ſulphur. Even now, alchemiſts, and others w
have only confuſed id as of chemiſtry, from reading
chemical books, talk inceſſantly and deciſively of ſulphu

To Beccher, and ſtill more to the illuſtious Stahl,
owe the ſimple, clear, and preciſe ideas which we n
have of the ſeveral kinds of inflammable ſubſtances, form
ly confounded under the general name of ſulphur. By
ſagacious diſtinction they have made between the pure a
ſimple inflammable principle, and the more compoun
bodies which contain it, and owe their inflammability to
we acquire a knowledge of the true theory of ſulphur a
of all inflammable ſubſtances.

Since Stahl has unfolded this ſublime theory, we kn
that the inflammable principle is identical, always ali
and the ſame in every body; that this principle by its co
bination with different ſubſtances produce all the inflamm
ble matters which we know. Oils, fats, reſins, bitume
ardent ſpirits, coals, metals, ſulphur properly ſo called,
common ſulphur, are ſo many compounds, all which h
the common property of burning, becauſe they all cont
the principle of inflammability; but which differ in other
ſpects, becauſe this principle is united to different ſu
ſtances, and in different proportions.

Stahl has eſtabliſhed theſe important truths, chiefly
examining, by decompoſing, and by re-compoſing comm
ſulphur, and by demonſtrating from the moſt ſatisfact
experiments, that this ſulphur conſiſts of vitriolic a
united with the pureſt and ſimpleſt inflammable princip
We ſhall relate, as ſhortly as we can, the reſults of his
ſearches upon this ſubject.

Nature probably forms, and combines daily, mine
ſulphur within the earth. This ſubſtance is abundan
diffuſed in many places, eſpecially where metallic miner
exiſt. Sulphur almoſt pure, called *native ſulphur*, is fou
in volcanos and in grottos, where it is ſublimed in form
tranſparent cryſtals. But the greateſt quantity of ſulph
which exiſts naturally, is combined with metals in ores, a
eſpecially in pyrites. As ſulphur is fuſible and volati
it is procured from theſe minerals by diſtillation and ſub
mation. *See* SMELTING *of* ORES.

Sulphur, ſuch as it is in commerce and in arts, is o
pale yellow or citron color, of a diſagreeable and pecul
ſmell, which is rendered more ſenſible when the ſulphur
heated or rubbed. By rubbing, ſulphur is electriſed.
ſpecific gravity is much greater than that of water, and l
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than that of earths and ſtones. It is brittle and pulverable; although it may alſo be eaſily ſoftened, as we ſhall afterwards obſerve.

Sulphur ſeems to be incapable of receiving any alteration from air or from water, ſeparately or conjointly, nor even from fire in cloſe veſſels. Sulphur, expoſed to heat in a ſubliming veſſel, is melted with a very gentle heat, and then is ſublimed, and adheres to the capital, forming ſmall very fine needle-like cryſtals, called *flowers of ſulphur*. This ſublimed ſulphur is eſſentially the ſame as that which has been only melted: and it may be thus ſublimed many times without alteration. If ſulphur, which has been expoſed to no more heat than ſufficient to melt it, be cooled very gradually, it cryſtallizes in form of many needles croſſing each other. Some of theſe pointed cryſtals may alſo be obſerved in the interior parts of the lumps of ſulphur which have been melted and caſt into cylindrical moulds, as they are commonly ſold; becauſe the center of theſe cylindrical rolls is more ſlowly cooled than the ſurface. Sulphur alſo gives this needle-like form to cinnabar, to antimony, and to many other minerals containing it.

Sulphur is inflamed and burnt by expoſure to fire and to air. But the phenomena which it exhibits are different according to the manner of its combuſtion. When it is very hot and burns quickly, its flame is ardent and capable of kindling inflammable bodies, but is always bluiſh, not very luminous, and not accompanied with any ſoot or ſmoke, but with an acid vapor of a penetrating and ſuffocating ſmell. This vapor, confined by means of a glaſs bell, and received into the vapor of water introduced for that purpoſe into the ſame bell, is called *ſpirit of ſulphur*, which we ſhall afterwards ſhew is the vitriolic acid, that is at firſt volatile and ſulphureous, from the ſmall quantity of inflammable principle that it ſtill retains, but which afterwards becomes pure vitriolic acid.

If, on the contrary, ſulphur is burnt in open air, but very ſlowly, its flame is ſo little luminous, that it can be perceived only in the dark, like a ſmall bluiſh glimmering light; and ſo little ardent, that it cannot kindle the moſt inflammable ſubſtances. Mr. Beaumé proves this truth by a very fine and curious experiment, in which he burns all the ſulphur that is contained in gun-powder without kindling the powder. When this experiment is made, a tile muſt be equally heated and to a certain degree, that is, a little more than is requiſite for the ſucceſs of the experiment.

ment. Upon this tile, thus heated, ſome grains of gun-powder are thrown, to diſcover the degree of heat; and if the heat be too great, the powder detonates, from time to time, as is uſual. More powder is thrown on the tile, till this be ſo much cooled, that the powder does not fulminate, but only emits a white ſmoke. If the tile and powder be carried in this ſtate to a dark place, the vapor, which ſeemed to be a white ſmoke, will then appear to be a true flame, but very bluiſh and faint; which will continue till all the ſulphur of the powder be conſumed, if the tile remains ſufficiently hot for that purpoſe.

We may eaſily perceive, that when the ſulphur burns thus weakly and ſlowly, a part of its inflammable principle is diſſipated without inflammation, and that conſequently the acid which is diſengaged by that combuſtion, ought to be more volatile, penetrating, and ſulphureous, than it is when the inflammation is more rapid. Hence, when we would obtain much volatile ſulphureous acid by burning ſulphur, as for the whitening of ſtuffs by the vapor of ſulphur, it muſt be burnt very ſlowly, as Stahl has well remarked.

As nothing remains after the burning of ſulphur, unleſs ſome extraneous body happens to be mixed with it; and as, during this combuſtion, nothing is perceptible but two matters, one of which is deſtroyed by the inflammation, and another which has the properties of the vitriolic acid; we may conclude, that ſulphur is compoſed of an inflammable matter, and of vitriolic acid. But the examination of the other properties of this ſubſtance will render our knowledge of its nature and its principles more compleat and accurate.

Sulphur heated ſo much as to burn, and thrown while melted and burning into water, is very quickly fixed or rendered ſolid; but in this experiment it acquires a conſiderable degree of ſoftneſs, which indeed only laſts a certain time; after which the ſulphur recovers its natural conſiſtence and brittleneſs.

Pure acids ſeem to have no action upon ſulphur, eſpecially in the humid way. But Mr. Beaumé has obſerved, that if concentrated vitriolic acid be poured upon ſulphur, and heated to a certain degree, this ſulphur will liquefy and appear in the water like an oil; and when it is cooled, it will have a green color; which ſeems to ſhew ſome action of the acid upon the ſulphur. But this ſulphur is not in any other reſpect changed.

Alkalis

Alkalis fixed and volatile, and even calcareous earths, dissolve sulphur, render it more or less soluble in water, and form with it compounds called *livers of sulphur*. The sulphur may be separated and precipitated, by means of an acid, from these substances; in which case, it appears, as before, only much divided.

This experiment shews that sulphur is not decomposed by uniting with alkalis. Nevertheless, the strong fetid smell of liver of sulphur, and the facility of decomposing sulphur while it is thus united with an alkali, shew that, in this combination, the connexion of its parts are weaker than when it is uncombined. *See* LIVER *of* SULPHUR.

Sulphur detonates with nitre, from its inflammable principle, and is then decomposed by the combustion of this principle. But in this detonation we perceive only the two principles of sulphur above-mentioned. Its phlogiston, together with that of the nitrous acid, maintains the flame of this detonation, and the acid of the sulphur is afterwards found to be combined with the alkali of the nitre, with which it forms a vitriolated tartar, called *sal polychrest of Glaser*. This is completely proved in the experiment of the *clyssus of sulphur*. *See* CLYSSUS.

Sulphur unites easily with all metallic matters, excepting gold, platina, and zinc; at least we have not found the means of uniting it with these, directly, and without some intermediate substance. The degrees of affinity with which sulphur combines with those metals to which it may be readily united, are different; for it not only unites more easily and abundantly with some than with others, but it also quits those with which it has a less affinity, to unite with others to which it has a stronger affinity.

The affinities of sulphur, according to Mr. Geoffroy's Table, are, fixed alkali, iron, copper, lead, silver, regulus of antimony, mercury, and gold; and according to Mr. Gellert's Table, they are, iron, copper, tin, lead, silver, bismuth, regulus of antimony, mercury, arsenic, and cobalt: gold and zinc are marked in this Table as being incapable of uniting with sulphur.

The compounds formed by sulphur with different metals are different; but all of them possess a metallic lustre, without any ductility: these combinations of sulphur and of metals are very frequently found in a natural state. Almost all the metals which we dig from the earth are naturally found combined with sulphur, forming most of the ores and metallic minerals.

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The properties of the combinations of ſulphur with metallic matters have been little examined, becauſe theſe combinations are not of any uſe; but, on the contrary, when they are found, they muſt be decompoſed, that the metals may be obtained ſeparately from the ſulphur. Nevertheleſs, we know not only that metals have different degrees of affinity with ſulphur; in conſequence of which property, ſulphur may be and actually is, in many metallurgical operations, ſeparated from ſome metals by means of others, to which it is more diſpoſed to unite; but we alſo know that ſulphur facilitates the fuſion of hard and difficultly fuſible metals, ſuch as copper and iron; and that, on the contrary, it renders the ſoft and fuſible metals, as tin and lead, leſs eaſily fuſible. Theſe ſingular effects ſeem to proceed from the difference of the affinity of ſulphur to the ſeveral metals.

Sulphur may be ſeparated from metallic matters by ſeveral methods. Firſt, as ſulphur is volatile, and as theſe metallic matters are fixed, or at leaſt leſs volatile than ſulphur, the mere action of fire is ſufficient to ſeparate ſulphur from moſt metals. As this method is ſimple, and not expenſive, it is generally employed to ſeparate ſulphur from ores; which effect is produced by the *torrefaction* or *roaſting* of theſe ores. We muſt, however, except the ore of mercury, or native cinnabar, and alſo the combinations of arſenic with ſulphur, which cannot be decompoſed without an intermediate ſubſtance, from the great volatility of mercury and of arſenic; although, perhaps, it would not be impoſſible to ſeparate the ſulphur from thoſe compounds, without an intermediate ſubſtance, by a heat carefully applied, long continued, and with acceſs of air.

Secondly, ſeveral combinations of ſulphur with metals may be decompoſed by means of acids, which diſſolve the metallic matter, without attacking the ſulphur. But in ſeveral of theſe compounds, the ſulphur defends the metal from the action of the acids; and this ſeparation by acids does frequently not ſucceed, or ſucceeds only imperfectly. Crude antimony is one of the ſulphurated metallic ſubſtances from which ſulphur may moſt eaſily be ſeparated by means of aqua-regia. This menſtruum ſeizes readily the regulus of antimony contained in mineral antimony, and ſeparates from it the ſulphur, which then appears in form of a white powder.

Laſtly, we may, as we have already ſaid, ſeparate ſeveral metals from ſulphur by means of other metals, to which the

ſulphur

lphur has a greater affinity. This ſeparation is practiſed ſeveral operations, as in the *dry parting*, the *purification of ld by antimony*, the *decompoſition* of *cinnabar*, of *orpiment*, d of *crude antimony*. *See the articles* ESSAY *of* ORES; RES PYRITES; SMELTING *of* ORES; *and all the articles of ſeveral metals and ſemi-metals.*

Oils and oily matters, of whatever nature, are all capable acting upon ſulphur, and of diſſolving it. Several ſolu-ns of ſulphur in eſſential oils are uſed in pharmacy, ich have been named from the oils employed; as *terebin-nated balſam of ſulphur*, and *aniſated balſam of ſulphur*; d other ſolutions have been made of ſulphur in expreſſed eet oils, as that in the oil of nuts, called *Rulland's balſam ſulphur*.

Sulphur cannot be diſſolved in oils, according to Mr. aumé, without a heat ſufficient to melt it. A larger antity of ſulphur is kept diſſolved in the oil while hot n when cold; and accordingly, when oil has been ſatu-ed with ſulphur by means of heat, a part of the ſulphur arates from it when it cools, in the ſame manner as many s, kept diſſolved in hot water, are cryſtallized when the ter becomes cold. The analogy betwixt the ſalts and phur in theſe inſtances is alſo obſervable in this reſpect, t when the oil in which the ſulphur is diſſolved is very dually cooled, the ſulphur cryſtallizes regularly, as ſalts in ſimilar circumſtances.

Sulphur is not decompoſed by the union which it con-cts with oils, when no more heat is applied than is ne-ſary for the ſolution. For the ſulphur, when ſeparated m the oil, is found to be poſſeſſed of all its properties. appears, however, that the connexion of its principles is ſome meaſure altered by this combination; at leaſt, if may judge from the color and ſmell of the balſams of lphur, which are different from thoſe of the ſulphur, or of e oil.

But when the balſams of ſulphur are diſtilled with a heat pable of entirely decompoſing them, the ſulphur itſelf is en alſo decompoſed. For according to an experiment ade by Homberg, and ſome other chemiſts, the ſame inciples are obtained by this diſtillation continued till the atter in the retort be dry, as are obtained from a combina-on of pure vitriolic acid with oils. Theſe principles are, ſt, a portion of oil, when the oil of which the diſtilled lſam is compoſed was an eſſential oil; then ſome volatile lphureous acid, which is at firſt watery, and afterwards

becomes

becomes ftronger; along with this acid more oil rifes, whic becomes more and more thick towards the end of the difti lation; and laftly, when the retort has been red-hot, nothin remains but a fixed coal.

From the above-mentioned products we find, that th fulphur and part of the oil are decompofed in this diftill tion. The vitriolic or fulphureous acid certainly proceed from the fulphur: for no quantity of that acid can be ob tained from any kind of oil, nor from any pure vegetable animal oily matter. The water contained in this fulphure ous acid is evidently a part of the water which is a princip of the oil: for the vitriolic acid of the fulphur being in ftate perfectly concentrated and dry, as fhall be afterward fhewn, could not otherwife contain fo much water as does in this operation. Laftly, the coal which remain after the operation, is a portion of the earth that is a princip of the oil, intimately united with fome of the inflammab principle either of the oil or of the fulphur, or moft pro bably of both.

In this mutual decompofition of fulphur and oil, th concentrated acid of the fulphur feems to attack the water principle of the oil, while its phlogifton, which by th new union lofes much of its adhefive power, is partly di engaged, and confounded with the phlogifton of the oi Thus the fulphur is changed into volatile fulphureous acid And probably alfo a certain quantity of inflammable prin ciple is difengaged in this experiment, and is diffipated i vapors. Such appear to be the phlogiftic vapors, which kindling at once, produce the terrible explofions that fome times happen when the combinations of oil and of fulphu are carelefly heated. Hoffman relates a fingular inftance o an explofion of this kind, which happened in a laboratory where balfam of fulphur had been left in a matrafs upon th fire.

Spirit of wine does not act fenfibly upon fulphur, unlef thefe two fubftances be applied to each other in the ftate o vapor, as the Count de Lauraguais difcovered. Man combinations, now believed to be impoffible, might b effected by employing the moft powerful means in chemiftry namely, an extreme divifion and feparation of integran parts, as the Count de Lauraguais has done in the above mentioned fine experiment. By this means chiefly, w may arrive at great difcoveries. From the above-mentione properties of fulphur we learn, that this fubftance is com pofed of vitriolic acid and phlogifton. Stahl demonftrate

thi

his important truth so clearly and compleatly, as to shew he true state, and even the proportion of the principles of ulphur, not only from its analysis, but also by its artificial ompoſition, of which we shall now speak.

The process by which this chemist made sulphur exactly milar to native sulphur, consists in mixing and melting ogether in a crucible equal parts of fixed alkali and of vi- iolated tartar, to which is added a quantity of powdered harcoal equal to a fourth part of the weight of the salts. The matter is to be stirred with an iron rod, that the char- oal may be well mixed with the salts; the crucible is to e covered; and a pretty strong heat is to be suddenly pplied, and continued during a very short time. The rucible is then to be removed from the fire, and the melted atter is to be poured upon a stone previously greased. This matter, which sparkles when it is poured, is coagulated y cold, and becomes a brittle mass, of a deeper red color an ordinary liver of sulphur; but it has the smell, the lubility, the deliquescency, and all the other properties liver of sulphur. By dissolving it in water, and by add- g any acid to the solution, an artificial sulphur will be ecipitated, which being collected and dried, is found not differ from natural sulphur.

The color of this dry liver of sulphur is redder than that the ordinary preparation of that name; and when dis- lved in water, its solution is of a deep green color, in hich respect also it differs from the ordinary liver of sul- hur. These differences proceed from some foreign matter nited with the liver of artificial sulphur; and this foreign atter is a part of the charcoal employed in the process for aking the sulphur. For the whole quantity of charcoal lded not being converted into sulphur in this process, me part of it is dissolved by the liver of sulphur as soon s this is formed; charcoal being soluble in liver of sulphur, s the younger Mr. Rouelle has shewn.

We should be much mistaken if we believed, that the ulphur obtained in this operation existed ready formed in ny of the substances employed, and that it is only extracted om these. Glauber had, before Stahl, performed this peration, by employing his *sal mirabile* instead of vitrio- ated tartar; but from his ignorance of the true theory, he ell into this mistaken opinion. Boyle also, having pro- ured sulphur by distilling to dryness a mixture of vitriolic cid and oil of turpentine, did not believe that he had roduced this sulphur, but only that he had separated it from

from the fubftances employed. On the contrary, we know certainly from many proofs, that not a particle of fulphur exifts in vitriolic acid, nor in neutral vitriolic falts with bafis of fixed alkali, nor in very pure alkalis, nor in any oil, nor in any vegetable coal; and confequently the fulphur obtained in thefe operations is a new product, refulting from the union of the vitriolic acid with inflammable principle of the vegetable coal, as Stahl has advanced.

The fixed alkali mixed with vitriolated tartar in this procefs is not abfolutely neceffary; for fulphur may be produced merely from any vitriolic falt with any inflammable matter, made red-hot together: but the alkali is ufeful in this procefs, by facilitating the fufion of the vitriolated tartar, and by preventing the diffipation and combuftion of moft of the fulphur, as foon as it is formed. This alkali unites with this fulphur, and forms a liver, in which the fulphur is lefs difpofed to burn, and be diffipated, than when it is not engaged with any fixed and incombuftible body.

Although, rigoroufly fpeaking, the vitriolic acid itfelf, when difengaged, and treated properly with any combuftible body, can always produce fulphur; neverthelefs, in this operation, an acid engaged in fome bafis to which it adheres ftrongly ought always to be employed; fuch is the acid in vitriolated tartar, in Glauber's falt, and even in almoft all neutral vitriolic falts with earthy and metallic bafes; becaufe vitriolic acid cannot contract with the inflammable principle the intimate union which is requifite for the production of true fulphur, excepting it be deprived of all the water that is not neceffary to its faline effence; that is to fay, in its higheft degree of concentration, and even in a dry ftate. Befides, if a red heat be not abfolutely neceffary to effect this combination, as the fulphur formed in the folution of fome metallic matters by vitriolic acid fhews, it is neverthelefs very ufeful. But when a difengaged vitriolic acid is employed; as, for inftance, when a mixture of this acid with an oil is diftilled; the greateft part of the acid is converted into volatile fulphureous acid, while any moifture remains in the mixture, and the fulphur is not produced till towards the end of the operation, when the matter in the retort is dry; and then the concentrated remaining portion of vitriolic acid, uniting with the phlogifton of the earthy coal of the oil, forms the fulphur.

Hence, fulphur may be more copioufly and quickly made, by applying to a coal vitriolic acid engaged in fome bafis, which

enders it so fixed that it may, by fire, be deprived
perfluous water, and even be made red-hot, than
ying this acid in any other manner. Accordingly
rocess is the best. These considerations on the best
of making sulphur are of little value, because
ulphur is plentiful and cheap. But the discovery
hur can be thus made, and the theory which Stahl
concerning this subject, are very important. For
nce we not only learn the nature of sulphur, of
e had an imperfect, and even false idea; but,
nuch more valuable, we may thence draw a number
mportant and very general inferences, the chief of
e shall now mention.

vitriolic acid and the inflammable principle cannot
phur by combining together; unless they both be
of all moisture, and be perfectly dry. Hence no
ble body which contains in its composition water,
oils and ardent spirits, can form with this acid,
but only a volatile sulphureous acid, till these in-
e matters be decomposed, and reduced to a state of
ich is one of the dry combinations of the inflam-
inciple.

lly, the inflammable principle of all combustible
always capable of forming sulphur with the
acid, provided it be, or can be made, dry. Thus
irits, oils, and oily matters, or rather the coals of
substances, and all combustible metals, do always
hur when treated properly with vitriolic acid; and
the nature of the combustible body be which trans-
phlogiston to the acid, the sulphur resulting from
ys the same, and always perfectly similar to natural
Hence an important proposition is inferred, that
inflammable principle exists, which is always the
ether it resides in resins, in bitumens, in oils and
als, or in metals. For if the inflammable prin-
all these combustible bodies was not the same
these bodies might form different sulphurs
iolic acid, which we find from experience they
.

y, vitriolic acid always quits any body with which
to be combined, when it can unite with the in-
principle of any other body, and with this prin-
ns sulphur when it is properly applied. Hence,
has a greater affinity with the inflammable prin-
n with any other substance; and hence we may

 discover,

discover, by means of phlogiston, the vitriolic acid, wit whatever substances it may be combined; and reciprocall we may, by means of vitriolic acid, discover the inflam mable principle in all bodies in which it exists in a com bustible state.

Fourthly, the principles and properties of sulphur bein known, we may deduce from these properties a more ac curate knowledge of the particular nature of the inflam mable principle, by comparing the difference betwe sulphur, volatile sulphureous acid, and pure vitriolic aci From this comparison we find, that the smell and color sulphur, its volatility, its constant dryness, its unsolubilit in water, which properties do not belong to vitriolic aci are produced by the inflammable principle, that possesses a these qualities in itself, or that is, at least, capable of com municating them to the compounds in the combination which it enters. *See the Article* PHLOGISTON.

Fifthly, we have reason to believe, that the inflammab principle possesses eminently the above-mentioned properties for we know that the quantity of it in sulphur is much le than the quantity of the vitriolic acid. Stahl has ma a fine experiment to discover nearly the proportion of th two principles of sulphur. This experiment consists i putting a quantity of powdered liver of sulphur upon a earthen-ware plate, and placing this plate upon a fire s gentle that the liver of sulphur shall not be melted, nor eve so softened that it can run into lumps. This powd must be stirred, and the fire must be encreased towards th end, till no smell be perceived. The remaining matt is to be dissolved in water, and by crystallization a very pu vitriolated tartar is formed.

In this operation, the inflammable principle of the sul phur is gradually dissipated without any sensible combustion and its acid combines, or remains combined, with the alka of the liver of sulphur. But we must observe, that t render this experiment exact, and to draw from it accura conclusions, the following conditions are required: 1st, w must know precisely the quantity of sulphur contained in th liver of sulphur employed; 2dly, the liver ought to contai rather too much than too little fixed alkali, that there ma be certainly enough of it to saturate all the acid of th sulphur; lastly, no part of the sulphureous acid must escap during this decomposition; and therefore no smell of th acid, but only that of the liver of sulphur, which is ve different, ought to be perceived. To prevent this dissip

tio

of volatile acid, we muſt proceed very ſlowly; and operation accordingly requires a long time. Mr. ndt, who has carefully repeated it, found from the ntity of vitriolated tartar obtained by this method, that, ulphur, the proportion of inflammable principle is to of the vitriolic acid as three to fifty; that is, that ſulphur contains only one ſixteenth of its weight of mmable principle.

ch is the ſtate of our actual knowledge concerning the re and principles of ſulphur, which Stahl has rendered compleat and accurate. We find that ſulphur is a pe- r combination of the pureſt inflammable principle with olic acid; that not a particle of oil is contained in it; it is therefore very different from bitumens, with h it has been long confounded; that, ſtill more impro- , the name of ſulphur has been given to all other mmable bodies, which are entirely different from it; we ought therefore to confine the name of ſulphur to compound formed of pure vitriolic acid and pure phlo- n, unleſs we would apply it, as the ancient chemiſts done, to the inflammable principle itſelf, which they d the *principal ſulphur*; but in this caſe we ought to another name to mineral ſulphur.

et us remark, nevertheleſs, on the ſubject of the name *ur*, that as other acids beſides the vitriolic can alſo ract an intimate union, and form compounds with pure giſton, this name may be generally applied to all pounds of pure acid and phlogiſton, which may be nguiſhed from each other by adding the name of the ; as *vitriolic ſulphur*, *nitrous ſulphur*, and *marine ſul-* , if any ſuch ſulphur does exiſt: but let us alſo rk upon this ſubject, that we can give this name of *ur* to thoſe compound bodies only which do not contain oil; this condition being eſſential to the ſulphureous bination; and conſequently, that we cannot admit of *us ſulphur*, of *tartareous ſulphur*, or of others of this re containing vegetable acids, which cannot ever form uly ſulphureous combination, on account of the oil ch enters into their compoſition as an eſſential principle.

the articles ACID (VITRIOLIC), ACID (VOLATILE PHUREOUS), DETONATION *of* NITRE, LIVER *of* SUL- JR, *and* PHLOGISTON.

The uſes of ſulphur are conſiderably extenſive in chemi- , in medicine, and in arts. The liver of ſulphur is

 employed

employed in chemiſtry for ſeveral ſolutions, which may be ſeen at the article LIVER *of* SULPHUR. Sulphur is alſo uſeful for ſeveral fuſions, precipitations, and ſeparations of metals and minerals, as we have already mentioned. Laſtly, as ſulphur contains a very large quantity of vitriolic acid, a method has been found, and is now practiſed, of extracting from it this acid, by burning ſulphur in cloſe veſſels with the addition of ſome nitre, and by an operation ſimilar to that of the clyſſus. *See* CLYSSUS.

Sulphur is employed in medicine, both internally and externally, for aſthmatic diſeaſes of the breaſt, and for ſeveral diſeaſes of the ſkin of the nature of the itch. The internal preparations of ſulphur are, flowers of ſulphur, waſhed ſulphur, magiſtery of ſulphur, tablets, balſams, livers of ſulphur, and others, in ſome of which this ſubſtance is not altered, but only purified and divided, and in others, is combined and aſſociated with other ſubſtances, without reckoning the ſulphureous combinations of antimony and of mercury.

Some phyſicians and chemiſts, conſidering that ſulphur is unſoluble in water, and capable of reſiſting the action of moſt menſtruums, have advanced, that it can produce no effect when taken internally, ſingle and unaltered: but this aſſertion ſeems to be without foundation; for we are certain that the ſweat and perſpiration of thoſe who take ſulphur internally have a ſmell evidently ſulphureous. Beſides, ſulphur is much more ſoluble than is generally believed. It is attacked by all oily and ſaponaceous ſubſtances, and conſequently by almoſt all animal liquors.

We cannot eaſily form a very diſtinct and clear idea of the manner in which ſulphur acts internally upon our bodies; but from obſervations made upon its effects, it appears to be dividing, ſtimulating, and ſomewhat heating: it principally acts upon the perſpirable parts of the body, the chief of which are the ſkin and lungs; and from this property, it is particularly uſeful in ſome diſeaſes of these parts.

Sulphur is alſo a powerful repellent, as appears from its curing ſeveral kinds of itch, merely by external application, in form of ointments and pomatums.

Several mineral waters, which are drank, or uſed as baths, for ſome diſeaſes, owe their good qualities to ſulphur contained in them. Such are the waters of Cauterets, of Mont D'or, of Aix-la-Chapelle, and of Saint-Amand. Accordingly, theſe waters are employed in ſeveral diſeaſes

reaſt and of the ſkin. Laſtly, ſulphur combined with r ſubſtances may contribute to their medicinal powers. he articles BALSAM of SULPHUR, CINNABAR, ETHIOPS ERAL, MINERAL WATERS, LIVER of SULPHUR, MES MINERAL.

lphur is alſo uſed in ſeveral arts. By means of it fine eſſions of engraved ſtones are taken. Matches are ed of it; and its utility as an ingredient in the prepa- n of gun-powder and fire-works is well known. y, it is uſed for whitening wool, ſilk, and many matters expoſed to its vapor during its combuſtion, olors and redneſs of which could not be deſtroyed by other ſubſtance, but are quickly effaced by this acid r.

ULPHUR (GOLDEN) of ANTIMONY.

len ſulphur of antimony is a mixture of ſulphur and us of antimony, of an orange color, which is obtained ſſolving the ſcoria of regulus of antimony, and by pre- ating this ſolution by means of an acid.

e may ſee at the article REGULUS of ANTIMONY, this ſcoria is a liver of ſulphur, containing a certain tity of the reguline part of antimony. When there- this antimoniated liver of ſulphur is diſſolved in water, when any acid is added to this ſolution, the acid ſeizes the alkali of the liver of ſulphur, by means of which ſulphureous and reguline parts of the antimony were ſuſpended in the water, and at once precipitates both .

though this precipitate be compoſed of ſulphur and us of antimony, as crude antimony alſo is, its proper- are nevertheleſs very different from thoſe of this mineral. precipitate has no metallic color or appearance, and ſides poſſeſſed of a powerful emetic quality, which the nony has not. Theſe differences proceed from the ur of the precipitate not being united with the reguline in the ſame manner, nor ſo intimately, as in crude nony. In the golden ſulphur, the reguline part is only d with the ſulphur, and is in a great meaſure diſengaged uncombined; whereas in crude antimony, it is inti- ely connected and united with the ſulphur.

Golden ſulphur has ſome reſemblance to kermes mineral: it differs eſſentially in ſome circumſtances, namely, a ſmall portion of fixed alkali remains united with kermes when well prepared, that is, not too much hed, and that the proportion of ſulphur is greater in

kermes than in golden ſulphur. To be convinced of th differences, we need only to attend to the circumſtan which accompany the precipitation of theſe two ſubſtanc Kermes is precipitated ſpontaneouſly without addition any acid, and merely by the cooling of the ſolution of antimoniated liver of ſulphur which contains it: it is the fore compoſed of the reguline part, but eſpecially of ſuperabundant quantity of ſulphur, which the alkali can keep diſſolved, but by means of a heat almoſt equal to t of boiling water: whereas the ſolutions of antimoni liver of ſulphur, not only that of kermes itſelf, but that of the ſcoria of the regulus of antimony which depoſited its kermes by cooling, contain no more ſulp than the alkali can keep diſſolved without heat, wh quantity is therefore leſs than in the kermes. Beſides, acid neceſſary for the precipitation of the golden ſulp ſeizes all the alkali; whereas a little of it always adhere the kermes during its precipitation.

The golden ſulphur of antimony was much emplo when preparations of antimony were firſt introduced medicine, but is now pretty much neglected; and ju becauſe the kermes and emetic tartar produce the ſ effects more gently and more uniformly. *See* ANTIMO *and* KERMES (MINERAL.)

TALK. *See* MICA.

TAR. *See* PITCH.

TARTAR. Tartar is a concrete, oily, veget acid, which is depoſited and is cryſtallized in liquors have undergone the ſpirituous fermentation. It is a kin eſſential ſalt of wine.

Probably wines of all kinds depoſite a greater or quantity of tartar; but the wine of grapes is one of t which furniſh the moſt of it, and the tartar of this win almoſt the only one that is employed or known.

All wines of grapes do not furniſh an equal quantit tartar. Some of them depoſite it abundantly, and ot but a ſmall quantity only. Sometimes a longer and ſomet a ſhorter time is required for the depoſition of ta Generally a long time is required, and alſo an inſen kind of fermentation, which continues in the wine a l time after the ſigns of the ſenſible ſpirituous fermenta have ceaſed. *See* WINE.

artar is deposited on the sides of the casks contain-
. On these a hard crust is formed, which becomes
d more thick; and as a portion of the fine dregs
ine adheres to this crust, the tartar of white wine
greyish-white color, and is called *white tartar*;
of red wine has a red color, and is called *red*

, when separated from the casks on which it is
is mixed with much heterogeneous matter, from
is purified for the purposes of medicine and of
. This purification of tartar is performed at
er, and consists (as we find from a Memoir of M.
Professor of Medicine at Montpelier, printed
he Memoirs of the Academy for the year 1725) in
artar in pure water, in filtrating this water, and in
the saline matter to deposite by cold. By this
ration, the grosser impurities which adhere but
o the tartar are separated: but the crystals obtained
operation are still red, and charged with an oily
xtraneous to the tartar.

this extraneous matter the tartar is purified by boil-
a water in which clay is diffused. By a second
and crystallization, very pure and white crystals of
e obtained; but they are small and ill-shaped, from
kness of their formation.

crystallization is partly performed by evaporation,
ly by cold. The part which crystallizes by evapo-
rms a saline crust upon the surface of the liquor,
eam of tartar; and the part which crystallizes by
ns small irregular crystals, called *crystals of tartar*;
name of cream of tartar has prevailed over the
o that it is at present applied also to crystals of tar-
signifies in general purified tartar.

of tartar has a taste sensibly acid; it reddens the
ors of vegetables; it may be saturated by uniting
of those substances which are capable of forming
ds neutral salts; and it may be afterwards sepa-
om these substances, and may recover its former
ice. Accordingly, we are certain that this saline
s an acid. Its property by which it is concrete and
zable, it receives from a portion of earth and oil,
ich it is intimately combined, and which approxi-
to the nature of neutral salts, especially in what
s the crystallizable quality and the solubility of these

Tartar, although acid, is not very ſoluble in water; it
even much leſs ſoluble than moſt of the perfectly neut
ſalts. According to Mr. Spielman's experiment, an oun
of diſtilled water can diſſolve only three grains of crea
of tartar, with the heat of fifty degrees of Fahrenhei
thermometer, which is equivalent to the tenth degree
Mr. Reaumur's. By help of a boiling heat, water diſſolv
much more tartar; but this tartar cryſtallizes very quicl
when the water ceaſes to boil. The oily part of the tar
ſeems to be the chief cauſe of its difficult ſolubility
water.

Tartar is in a great meaſure decompoſed and tota
changed by the action of fire. If cream of tartar be diſti
ed in a retort with a naked fire, a little phlegm will fi
riſe with a gentle heat. When the fire is gradually encreaſ
which muſt be done very cautiouſly, on account of the p
digious quantity of air that is diſengaged during this diſt
lation, an acid ariſes in form of white vapors, which
accompanied with an oil, at firſt thin, but afterwards mo
and more colored and empyreumatic. In the retort th
remains a coal, ſtrongly alkaline, equal in weight to tw
thirds of the tartar employed.

The acid obtained in this diſtillation is indeed oily,
therefore retains the character of a vegetable acid; but i
very different from the tartar itſelf. It is no longer cryſt
lizable; it is only an oily empyreumatic acid, ſimilar to wh
is obtained from all other vegetables by diſtillation in
naked fire. Theſe differences muſt be attributed to
portion of oil and of earth, which are ſeparated from t
acid by diſtillation. As to the reſiduum of coal, the fi
alkali, which it contains ready formed, is remarkable, co
ſidering that here there is no incineration in open f
which is generally neceſſary for the production of all
from almoſt all other vegetables. The cauſe of this d
ference probably is, that the acid of tartar is almoſt entir
changed into fixed alkali, is more diſpoſed to be alkali
than any other vegetable acid, whether this diſpoſit
proceeds from the quantity of earth and oil which are
timately mixed with it, or from ſome change produced up
it by fermentation. Mr. Spielman thinks, with mu
probability, that acids are changed into alkalis by the ſu
ſtraction of a part of their aqueous principle: and
nature and proportion of the conſtituent parts of tar
appear to be very proper to favour this ſubſtraction of

wat

principle by the action of fire. This subject is
cure, and would require a more profound exami-
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RTAR EMETIC, or STIBIATED
'AR. Thus is named the compound formed of
of tartar combined with the metallic part of anti-
when this is half deprived of its phlogiston. It is
and most used of all the emetic preparations of anti-
ecause the metallic part of this mineral, which gives
tic quality, is in a saline state, and is perfectly so-
water.

n analysis of *cream of tartar* has been published by Mr.
n the third part of the *Swedish Trans.* for 1770. If pow-
alk be added to a solution of cream of tartar in water till
vescence ceases, a copious white sediment will fall to the
and the liquor will, by evaporation, yield soluble tartar.
ves that cream of tartar is not an acid joined with im-
but a compound salt containing an alkali with an acid.
te sediment may be called *tartarous selenites*, being cal-
earth united with the superabundant acid of the cream of
f to this selenites, dilute vitriolic acid be added, a gypsum
ormed, and the liquor contains a pure acid of tartar. This
y, by evaporation, be made to form small white crystals,
o not deliquiate. By adding to this acid some vegetable
ll the effervescence is over, a transparent saline fluid will
ned; but if more acid be added, small crystals will con-
hich are cream of tartar.

s been generally believed that the alkali of tartar and
vegetable substances is merely the effect of the combustion
d in the preparation of the alkali. But M. Margraaf
s, that it exists in such vegetable substances previous to
mbustion, and shews that a fixed alkali may be separated
rtar by means of acids, without combustion. He dissolved
of cream of tartar in two gros of spirit of nitrre; and
e solution, which was clear and transparent, he obtained
of salt-petre; and by digesting, with a very gentle heat,
s of powdered cream of tartar with marine and vitriolic
he obtained a regenerated common salt, and a vitriolated
As these neutral salts are known to consist of their re-
acids united with the vegetable fixed alkali, it is evident
y must have received the alkali from the tartar with which
ls were mixed, and consequently that this alkali exists in
le substances independently of combustion. M. Mar-
btained also salt-petre by adding nitrous acid to salt of
erries, and to sawings of wood.

This

This preparation has been justly substituted for the golden sulphur, for the regulus, for the liver and glass of antimony, and for the powder of Algaroth. It is infinitely preferable to these preparations for the reasons mentioned; but unfortunately, the method of preparing this important remedy has not been fixed and determined. If in fact we consult the several Dispensatories, we shall find very different processes directed: the cream of tartar is employed by all; but some of them require that it should be boiled with the liver of antimony, others with the glass of antimony, and lastly, some with both of these preparations. The proportion also of the ingredients, the length of time of boiling, the method of crystallizing and drying the salt after it has been boiled, are different in different Dispensatories. In whatever manner cream of tartar is treated with the abovementioned preparations of antimony, we always obtain an emetic tartar much preferable to the ancient emetic preparations of antimony. But we are also certain, that the emetic tartars obtained by these several processes are sometimes more and sometimes less emetic; which difference is certainly a great inconvenience in so important a medicinal preparation as this is.

Probably this diversity has been occasioned by persons not considering, or not knowing, that the emetic quality of this preparation proceeds from the metallic earth being dissolved by the acid of tartar, and forming with it a kind of soluble tartar, a true neutral salt, no less capable of a very exact saturation than the vegetable salt, the salt of Seignette, and all the other soluble tartars. For this saturation being a fixed point, and easily to be found, would probably have been universally prescribed, as is done for all other neutral salts, if it had been well known to have occurred in this instance. But as it is now sufficiently ascertained, we may hope that all the faculties of medicine will adopt it, that there may be hereafter only one kind of emetic tartar, always equally strong. Upon this subject we shall add some observations.

First, although regulus of antimony be essentially emetic, it nevertheless produces less effect than the liver or the glass of antimony, because it is less soluble. These two preparations, which are only the metallic earth of antimony deprived of a part of phlogiston necessary to the reguline state, are for that reason more easily soluble by acids than the regulus, and are consequently more emetic. But the glass is still more emetic than the liver, because it has less phlogiston;

Mr. Beaumé affirms from experiment, that this acid may be eafily faturated with the reguline part of antimony: and as the glafs of antimony is the moft emetic and moft foluble of all the antimonial preparations made by fire, we ought to prefer it to all other in the preparations of a perfectly neutral antimonial foluble tartar. For this purpofe, we muft mix together equal parts of cream of tartar and of porphyrifed glafs of antimony, or rather a larger quantity of the latter ingredient. This mixture is to be thrown gradually into boiling water; and the boiling muft be continued gently, till there is no longer any effervefcence, and till the cream of tartar be entirely faturated. The liquor is to be filtrated; and upon the filter we may obferve a certain quantity of fulphureous matter, together with fome undiffolved part of the glafs of antimony. When the filtrated liquor is cooled, fine cryftals will be formed in it, which are a foluble tartar perfectly faturated with glafs of antimony. The cryftals of this falt have the form of triangular pyramids *(k)*. They are tranfparent while they are moift; but by expofure to a dry air, they lofe a part of the water of their cryftallization, and become opake and white.

As the perfect faturation of acids requires conftantly a determinate quantity of any fubftance which they can diffolve, we fhould be certain, by faturating compleatly cream of tartar with glafs of antimony, that the emetic tartar thus prepared would conftantly contain the fame proportion of emetic antimonial parts. The cryftallizing and draining of neutral falts in general, is a good method for obtaining them in their moft perfect ftate: accordingly this falt ought to be firft cryftallized; but as by expofure to the action of air it is apt to lofe fome of the water of its cryftallization, it ought, immediately after it is cryftallized, to be well dried; and then it would remain unchanged. I have frequently adminiftered emetic tartar thus prepared, and I have always obferved, that it very well produces an emetic effect when taken from a grain to two and a half, or three, according to the conftitution of the patients.

Authors, who have given receipts for the preparation of emetic tartar, have differed, as we have obferved, not only

(k) The author probably means pyramids, the bafis of which is a triangle: for every pyramid muft evidently have, at leaft, four folid angles.

as

ne kinds and proportions of the antimonial prepara-
hich they direct to be boiled with cream of tartar,
as to the duration of boiling. Some of them re-
hat the boiling should last twelve hours, and others
few instants, believing, with Hoffman, that this salt
ptible of decomposition, and of losing its emetic
by a long-continued boiling. Mr. Beaumé has de-
d this matter by well-conducted experiments, which
at emetic tartar, like other metallic salts, is capable
g decomposed by other metals to which its acid has a
affinity than to the metallic basis, and that iron, parti-
, is capable of producing this effect upon emetic tartar;
f it be boiled a long time in an iron vessel, it is actually
osed, and the liquor is gradually changed into a tar-
tincture of Mars. But Mr. Beaumé also found that
tartar may be boiled during any length of time in
made of silver or of glass, without being decomposed.
results of these experiments of Mr. Beaumé are,
t any vessels ought not to be employed in the pre-
n of emetic tartar; that especially iron, and even
, ought to be avoided, for this latter metal is found
act a little upon emetic tartar; and that vessels of
r of glass ought to be used. 2. That as the inten-
the operation is to saturate perfectly the cream of
the boiling must be continued till this saturation be
l, which requires a long time when the glass of anti-
s grosly pounded, but a much shorter time when it is
orphyrised, as Mr. Beaumé practises.

must acknowledge that emetic tartar, prepared by
aturating completely the acid of tartar with glass of
ny, must be infinitely more uniform in its effects,
hat is obtained by any of the other processes hitherto
ed. Nevertheless, when we reflect on the nature of
ss of antimony, we cannot affirm that this emetic
ation, notwithstanding its perfect saturation, must
be of equal strength. Glass of antimony is made
ng the grey calx of antimony, calcined to a certain
. We know also, that if it be too little calcined,
all obtain an opake matter, that resembles the liver
han the glass; but that if it be too much calcined,
not be vitrified, nor even fused, by the most intense
But between the degrees of calcination which is suffi-
o give an opake fused matter, and the degrees when
ins to be unfusible, there are many intermediate degrees
cination, all of which are sufficient to produce glasses
of

of antimony; but these glasses differ in degree of transparency, intensity of color, and fusibility, according as the calcination has been more or less compleat. We cannot doubt that different glasses of antimony must be more or less emetic, and that perhaps different quantities of these glasses are required for the perfect saturation of the acid of tartar. Besides, we are not only ignorant of the degree of calcination which renders the glass most emetic; but also, if we did know it, we have no very certain method of attaining it precisely.

Hence, we are not certain that the emetic tartar, prepared by saturating tartar with glass of antimony, has always an uniform and constant emetic power. These considerations have determined me to search, among the several preparations of antimony, for one which should have the same advantages that glass of antimony has, of being convertible into a neutral salt by means of tartar, without the inconveniencies of its uncertain degrees of emetic strength; and I have found that the *powder of Algaroth*, or *mercury of life*, is capable of answering these intentions.

This preparation, which was formerly employed as an emetic, has been justly rejected with the other antimonials that have not a saline quality, because it has the same inconveniencies as these have. It occasioned accidents so terrible, that some physicians have affirmed, that it ought with more propriety to be called the *mercury of death* than the *mercury of life*. But these fatal effects do not prevent the possibility of rendering it a good remedy by a proper preparation; in the same manner as a glass of antimony, which given singly, produced much mischief, has saved many lives since it was converted by its union with tartar into a most efficacious remedy.

Two causes concur in rendering the powder of Algaroth a violent and uncertain remedy. The first is common to it with glass of antimony, and with all the other antimonial preparations that are not saline; and is, its want of solubility in water, for the reasons that we have assigned. The second cause of the violent and uncertain effects of powder of Algaroth is, that a certain quantity of marine acid remains united with it, and communicates to it a certain degree of caustic quality. But both these causes of the bad effects of this preparation may be easily and certainly removed. For, by washing it with a little fixed alkali, all the acid may be separated. And I have found from experiments, that the powder thus washed is altogether soluble by

o of tartar, and of being thereby convertible into
e emetic tartar, perfectly neutral; for which pur-
othing more is required than to boil it, and saturate
cream of tartar, and to treat it in the manner
irected for the preparation of emetic tartar with
antimony. We may easily perceive that powder
roth thus prepared, is a calx of antimony constant-
ne same degree of emetic strength. It is emetic,
the regulus of antimony first dissolved by marine
d afterwards separated from that acid, retains the
of phlogiston that is necessary to give an emetic
to the calx of antimony: but the quantity of phlo-
which it retains, and therefore its emetic power,
ways be the same: for the marine acid of the corro-
limate, which afterwards becomes the acid of the
f antimony, is always the same in quantity, and
grees of concentration and of activity: consequently
of antimony separated from it must always contain
l quantity of phlogiston; and is therefore much
le to glass of antimony, which contains sometimes
d sometimes less phlogiston.

ubstituting therefore powder of Algaroth to glass
nony, and by treating it in the manner above-men-
we may obtain the most uniform and certain emetic
at can be prepared: physicians, who must be sen-
the advantage of such a remedy, need not be
concerning its degree of strength. If it were once
they would have occasion only to attend to the
ty or irritability of the constitutions of their pa-
See the articles ANTIMONY, POWDER *of* ALGAROTH,
of ANTIMONY, *and also all the other preparations of*
.

RTAR (VITRIOLATED). Vitriolated tartar
tral salt composed of a vitriolic acid saturated with
d alkali of tartar, or with any other pure vegetable
kali.

salt is prepared by pouring vitriolic acid into a solu-
vegetable alkali, till no more effervescence appears,
the liquor becomes perfectly neutral, which may be
by the ordinary trial of syrup of violets. From
uor, filtrated and evaporated, small crystals are ob-
each of which has many sides, sometimes more,
netimes fewer; for the crystallization of this salt
uch in this respect. It is, in general, one of those
e form of whose crystals is the least constant. The
greatest

greatest number of the cryſtals of this ſalt appear to have been cubes, the angles of which have been cut off.

Vitriolated tartar is one of the ſalts which cryſtallize better by evaporation than by cold. It requires a large quantity of water to diſſolve it. According to Mr. Spielman's experiments, thirty grains only of this ſalt are ſoluble in an ounce of water with a heat marked by ten degrees above 0 in the ſcale of Mr. Reaumur's thermometer. Its taſte is moderately ſaline, and ſomewhat diſagreeable, but not acrid nor ſharp. It decrepitates, when heated ſuddenly and ſtrongly. It contains a ſmall quantity only of the water of cryſtallization, by means of which it cannot be liquefied; neither can it be fuſed but by a very intenſe heat.

As vitriolic acid has a greater affinity with the fixed alkaline baſis of the vitriolated tartar than with any other ſubſtance, excepting phlogiſton, and as this alkali has a ſtronger affinity with this than with any other acids, hence vitriolated tartar cannot be decompoſed but by means of the inflammable principle, as in the proceſs for making artificial ſulphur. Mr. Beaumé has indeed diſcovered, that vitriolated tartar may be decompoſed in the humid way by nitrous acid alone, which diſengages the vitriolic acid, and forms nitre with its alkali. But if we examine well all the circumſtances of this phenomenon, we ſhall find that this is no exception to the general rules concerning affinities, and that phlogiſton is the principal agent in this ſingular decompoſition, as Mr. Beaumé has ſhewn in the explication that he has given of it. (*l*)

Vitriolated

(*l*) Vitriolated tartar may be decompoſed by nitrous acid in the following manner, according to Mr. Beaumé. Equal parts of vitriolated tartar and nitrous acid are put into a matraſs and heated till the ſalt be diſſolved. From the liquor, when cold, true cryſtals of nitre may be obtained. Mr. Beaumé believes that this decompoſition is effected by means of the greater affinity of the nitrous than of the vitriolic acid to the phlogiſton, which, he ſuppoſes, enters into the compoſition of the vitriolated tartar: and he thinks that the reaſon why this decompoſition does not happen in the dry way, or by fuſion, as well as in the humid way or by cold ſolution, is, that the nitrous acid is in the former caſe diſſipated by the action of the fire. This ſingular fact, which ſeems to contradict a general opinion, namely that vitriolic acid is more diſpoſed than nitrous acid to unite with fixed alkali, is alſo confirmed by the intelligent and accurate

lated tartar may alſo be decompoſed by means of a
finity, when it is mixed with ſolutions of certain
acids. But as by phlogiſton only metals are diſ-
acids, we need not doubt that this principle has
influence in theſe decompoſitions.

itriolic acid has a greater affinity than any other
fixed alkali, we may therefore make vitriolated
applying that acid to any neutral ſalt compoſed of
nd a fixed alkali, as in the decompoſition of nitre;
fixed alkali has a greater affinity with vitriolic
any other ſubſtance, vitriolated tartar may be
made by applying a fixed alkali to any vitriolic
lt, the baſis of which is not fixed alkali. Ac-
, all vitriolic ſalts with baſes of volatile alkali,
ous, argillaceous, or metallic earths, may be de-
by fixed alkalis; and the compound formed by
ompoſitions will always be a vitriolated tartar,
of the fixed alkali employed in the operation,
e vitriolic acid of the decompoſed neutral ſalt.
may perceive, that vitriolated tartar is made in
mical operations.

the theory of theſe operations was underſtood,
e the fixed vegetable alkali was known to be the
whatever vegetable it was obtained, the ſeveral
tartars formed in different operations, and with
alkalis obtained from different vegetables, were
be different kinds of ſalts, and were diſtinguiſhed
nt names; as the *ſal de duobus*, *ſal polychreſt* of
canum duplicatum. But we conſider all theſe ſalts
e vitriolated tartar, with which the other names
mous.

lt is not of any uſe in the arts, and is but little
emiſtry. It is principally employed in medicine.
other neutral ſalts with baſes of fixed alkali, it
e in ſmall doſes, as a gros [72 grains]; and it is
when taken from ſix gros to twelve. The vitrio-
r which is prepared by decompoſing nitre with
cid called *ſal de duobus*, has been much celebrated

r. Margraaf, who further affirms, that in the ſame
treatment, vitriolated tartar, Glauber's ſalt, and
be decompoſed by marine acid. As marine acid is
t more diſpoſed to unite with phlogiſton than nitrous
c acids are, Mr. Beaumé's explanation of this ſingu-
oſition does not ſeem to be ſatisfactory.

as a remedy against the effects proceeding from an extrava-
sation of a milky humour, for which disease it has bee
considered as the best resolvent and evacuant. Neverthele
as Mr. Baron well observes in his Notes on Lemery, n
reason can be given for preferring this salt to other neutr
salts. On the contrary, as it is one of those which a
most perfectly saturated, its action and qualities must be le
effectual than most of these. *See the articles* ACID (VI-
TRIOLIC); ALKALI (FIXED VEGETABLE); CRYSTALLI-
ZATION; *and* SALT.

TERRA FOLIATA TARTARI; FOLIATE
EARTH *of* TARTAR. This name has been given impro-
perly, and merely for the sake of some earthy appearanc
to a *neutral acetous salt with basis of vegetable fixed alkali*,
to a combination of the acid of vinegar, saturated with th
alkali of tartar or of other vegetable matters. This sa
has also been called *regenerated tartar*, although it really
very different from true tartar, but only because the alka
of tartar is united with an acid, which in some respects
similar to the acid of tartar, but in others is very di
ferent, as may be seen at the articles TARTAR *and* VINE-
GAR.

The terra foliata is made, according to most dispensa-
tories, by pouring upon a quantity of alkaline salt of tarta
in a glass-cucurbit, a sufficient quantity of good distille
vinegar, at different times, to saturate all the alkali,
even a little more than is necessary for that purpose, an
till the effervescence entirely ceases. This saturated liqu
is to be filtrated, and evaporated to dryness, with a gent
heat. The dry salt thus obtained is to be dissolved in spir
of wine, and the solution is to be again evaporated to dry-
ness; by which means a salt is obtained more or less whit
of a silky appearance, and composed of small scales
leaves, from which it has been called *foliated*. When th
salt is dried, and while it is yet hot, it must be shut up in
well closed bottle, because it quickly becomes moist b
exposure to air.

When distilled vinegar is poured upon salt of tarta
little or no effervescence is made at first; but afterward
when more vinegar is added, the effervescence becom
so considerable, that some of the liquor will flow over th
vessel, if care be not taken. This effervescence is produce
by a large quantity of air that is disengaged during th
saturation. Accordingly the vapor extricated during th
effervescence is very *aerial*, and so pungent, that if it b
confine

ome time in a close vessel, and then set at liberty, rritating and suffocating as volatile alkali, oı lphureous acid, although it be really different er of these: for this vapor is nothing but r similar to the *gas* of spirituous mineral wa-

the saturation is advanced to a certain degree, escence diminishes, and even ceases entirely, he saturation be not yet compleated; the reason is, that the last portions of acid and of alkali y readily combine. The combination may be by frequently agitating the liquor, by which effervescence may be again renewed. When cannot by agitation be made to effervesce more, then allowed to stand during some time, as Mr. actises. This chemist, and very excellent ob- remarked, that the mixture deposites a certain f earthy matter proceeding from the fixed alkali, must be necessarily separated by filtration, to ry white foliated earth of tartar. He has also hat when the alkali employed is very pure, and the mixture of neutral salts, the saline matter by the process has no foliated or crystallized

e already remarked, that foliated earth of tartar is ent salt. This quality proceeds from the weak- union of the acid with the alkali; the cause of nt union is, that some oily and spirituous prin- nited with the acid in vinegar. The taste of the rth is sharp, pungent, almost a little caustic,

vapor which causes the effervescence in the pre- this salt, is the gas that is disengaged from all mild stances by means of any acid; and the humid part r is nothing more than some particles of the effer- or, which are forcibly thrown upwards by the rising hich form a small jet or shower above the surface rvescing liquor. *See* GAS. The reason that this e does not begin immediately upon pouring on the that a part of the alkaline salt employed is generally deprived of its gas, which part unites with the ably to the mild part of the alkali, and absorbs t is extricated from this latter part: and therefore austic part of the alkali be nearly saturated, little or ence can happen.

P 2 and

and partaking at the same time of the taste of vineg[ar] and that of fixed alkali. This salt is one of those that a[re] soluble in spirit of wine. It may be decomposed merely [by] the action of fire; and from it, as from any other aceto[us] salt, may be obtained by distillation, a radical vinegar, ve[ry] penetrating and very concentrated.

Foliated earth of tartar is little used but in medicine. [It] is considered as a powerful resolvent and aperitive; and [it] probably possesses these qualites, merely as it retains som[e] of the action of the acid and of the alkali, of which it [is] composed. Its dose is from fifteen or twenty to thirty-[six] grains, or even more, when no irritation is apprehende[d]. *See the articles* ALKALI (FIXED); SALT; SALTS (NEU-TRAL); *and* VINEGAR.

TERRA JAPONICA. *See* JAPONIC EARTH.

TEST, *and* TESTING. *(n)*

TIN. Tin is a metal, the color of which resembl[es] that of silver, but is darker and less white. It is softe[r,] less elastic, and less sonorous than any other metal, excep[t]-ing lead.

When it is bent backwards and forwards, it occasions [a] crackling sound, as if it was torn asunder.

Tin has, like other imperfect metals, a smell and a tast[e].

It is much less ductile than some harder metals; althoug[h] it may be beat into very thin leaves.

The tenacity of the parts of tin is not very considerabl[e;] since a wire of this metal, the diameter of which is $\frac{1}{10}$ [of] an inch, can support a weight of $49\frac{1}{2}$ pounds only.

It is the lightest of all metals, as it loses only $\frac{1}{7}$th part [of] its weight when immersed in water. It is very fusibl[e,] and requires for this purpose a heat much less than is suf[fi]-cient to make it red-hot.

With the heat necessary for its fusion it may also be ca[l]-cined, or at least deprived of so much of its phlogisto[n,] that it appears in form of a grey calx, which cann[ot] be reduced entirely to tin without the addition of some in-flammable matter.

Workmen call this imperfect calx of tin, *ashes of tin*, and those who travel in the country, casting tin spoon[s,] call it *dross of tin*. This they carefully skim off, preten[d]-

(n) TEST *and* TESTING. A test is a large kind of cup[el] used in operations for refining large quantities of gold and silv[er] by means of lead; and the operation is called *Testing*. S[ee] CUPEL; CUPELLATION; *and* REFINING.

in[g]

by to purify their tin. But they preserve this
drofs, and reduce it to tin by melting it with fome

ashes of tin, like other calxes of metals, may be
eprived of phlogiston, by a calcination continued
ore intenfe fire, by which means it becomes more
white, hard and refractory. It is then called
l is ufed in the arts for polifhing glafs and other
es.

f tin, very white and well calcined, is a very re-
ubftance. Its beautiful whitenefs and refractory
nder it capable of forming, together with fome
d vitrifiable matters, a white enamel, which is
white glazing or covering for delf-ware. *See*
ARE.

oft ordinary method of preparing this putty, is by
gether lead and tin, and expofing this mixture to a
at. Thefe two metals have been found to be
ly calcinable when mixed than when fingle. By
the calx thus obtained fome fand and vitrifiable
by fufing the mixture, a very beautiful white
ay be made: for lead does not, like tin, lofe its
ality by calcination.

expofed very pure tin, fingly, to a fire as ftrong
a glafs-houfe, during two hours, under a muffle,
covered teft; and having then examined it, I
covered with an exceeding white calx, which
to have formed a vegetation; and under this
reddifh calx, and a tranfparent hyacinthine glafs;
, at the bottom, a piece of tin unaltered. This
it was feveral times repeated with the fame fuc-

mixed with tin may be inflamed, and it haftens
oly the calcination of this, as it does of other im-
etals. The vapors which rife during the feveral
ns of this metal have generally an alliaceous or
fmell; becaufe tin generally contains fome arfenic,
argraaf has obferved.

gh tin be one of the moft calcinable metals by
fire, it is much lefs apt to ruft by the combined
air and water, than iron and copper. Its fur-
n it is clean and fhining, lofes indeed its luftre,
fhes quickly by expofure to air, but the flight kind
hich is there formed remains thin and fuperficial,

and does not advance fo deeply into the fubftance of th metal as the ruft of iron and of copper generally does. Henc tin is advantageoufly employed to cover many utenfils mad of thefe metals. *See* TINNING.

Every acid is capable of attacking or diffolving tin.

Vitriolic acid requires to be affifted by a certain degree o heat to diffolve tin efficacioufly. I have obferved, tha during this folution fulphureous vapors are raifed; and have even feparated fome black particles, which I hav found to be true inflammable fulphur. The production o extraction of this fulphur requires a particular examination *See* SULPHUR.

Nitrous acid attacks tin with very great violence, efpeciall when the metal is much divided. But when the acid is ver pure, it rather corrodes and calcines, than diffolves tin As the phlogifton of this metal is not very ftrictly engaged the nitrous acid chiefly attacks it by means of this prin ciple, which it feizes, and feparates from the tin, that thus reduced to an unfoluble white earth, or calx, de pofited at the bottom of the acid. This calx of ti made by nitrous acid appears to be as perfectly dephlo gifticated, as that which had been expofed during a lon time to fire. I have attempted unfuccefsfully to reduce to its metallic ftate. This calx makes a very good whi enamel.

The acid of common falt diffolves tin perfectly well b help of heat. I have obferved, that when I put a confider able quantity of fine granulated tin into a matrafs, an poured fome fmoking, and confequently colored, fpirit o falt upon it, that the acid quickly ceafed to fmoke, an loft its color; that it attacked the tin with a fenfible bu moderate effervefcence, and became faturated with i This acid diffolved more than half its weight of tin. Th vapors which rofe during the folution had a difagreeab arfenical fmell; and the folution when faturated was clea and colorlefs as water. Having kept the folution in a bottl I obferved that, during the winter, it almoft all cryftallize and that the cryftals became fluid during fummer. Som years afterwards a white fediment was formed in this folu tion.

Tin has a greater affinity with marine acid than fom other metallic fubftances which have alfo much affinit with this acid; for it feparates the marine acid from lun corn a, from corrofive fublimate, and from butter of ant mony. When tin is mixed, efpecially with corrofive fub limate

decompoſes this ſalt, even without heat; and
ire produced becomes moiſt by expoſure to air.
iſtilled before it has imbibed much moiſture, a
ing ſpirit of ſalt, called *ſmoking ſpirit of Liba-*
obtained. *See* SPIRIT (SMOKING) *of* LIBA-

cid retains much tin diſſolved, ſome of which it
g with it in diſtillation, as it does ſeveral other
atters. Accordingly, in this diſtillation, a con-
ine, metallic matter is ſublimed, that may be
ter of tin: which name has been given by ſome
o the ſmoking ſpirit.

e detail we have given of the ſolutions of tin by
d marine acids we may perceive, that the former
ves it of all its inflammable principle, but has
upon its dephlogiſticated earth; and that the
the marine acid upon this metal are quite the
Accordingly, when theſe two acids are united
forming an aqua-regia, they compoſe a men-
hich acts very efficaciouſly upon tin, on account
tivity of the nitrous acid, but which does not
metal, as nitrous acid ſingly does, becauſe the
this acid is moderated by the marine acid: hence,
nitrous acid is contained in aqua-regia, the
lar are its effects upon tin to thoſe produced by
id alone; and reciprocally with regard to marine

ſolution may be made of tin in aqua-regia, if
be given to the following particulars. A ſmall
nly of tin ought to be put into the acid, and no
d till the firſt piece be entirely diſſolved; becauſe
ch tin is added at once, the heat occaſioned by
on encreaſes the activity of the ſolvent ſo much,
n is as much calcined and precipitated as if pure
id had been employed; but when the tin is added
and the heat is thus reſtrained, the aqua-regia
charged with this metal, that it ſhall be thick
, like a liquid tranſparent reſin. The ſolution
ged has a yellow-reddiſh color.

ay obſerve, that in this ſolution there is a conſi-
antity of tin upon which the nitrous acid of the
has not exhauſted all its action, although this
n ſeems to be more than ſaturated; for I have
that when this liquor is heated, an effervеſcence

happens entirely similar to that which is occasioned during the solution of metals by acids. This effervescence lasts till the parts of the tin which were only half dissolved have been redissolved a second time; after which the solution is found to have lost its color. Sometimes this solution becomes quite fixed or solid when it cools, and appears like a firm jelly, and transparent as crystal.

All the solutions of tin are acid and corrosive; and may be decomposed by being diluted with much water; in which case, the tin is copiously precipitated in form of a white calx.

When a solution of tin is mixed with a saturated solution of gold, and when the mixture is diluted with a large quantity of water, a purple precipitate is formed, called *purple powder of Cassius. See that word.* This powder is employed for painting on enamels and on porcelain.

The solution of tin in aqua-regia, added to the tinctures of cochineal, of gum-lac, and of some other red tinctures, heightens the color of these, and changes it from a crimson or purple to a vivid reddish-yellow or fire-colored scarlet. Dyers call this solution of tin, with which they give a scarlet tinge, *the composition.* We may observe, that this color succeeds only with wool and other animal matters. Attempts have been made, but without success, to give this color to thread, to cotton, or even to silk, although this latter substance has many properties of animal matters.

I have also observed, that the larger quantity of nitrous acid is contained in the aqua-regia, which dissolves the tin, the nearer does the red color communicated to cochineal approach to the vivid yellow; so that the solution of tin made with marine acid alone, or with vitriolic acid, does only give to red tinctures a crimson color, as alum does. *See* DYING.

Vegetable acids, as vinegar and cream of tartar, are also capable of dissolving tin: but the properties of these solutions have not yet been well examined.

Tin, according to Mr. Geoffroy's Table of Affinities, has a stronger affinity with the acid of common salt than regulus of antimony, copper, silver, and mercury; because the combinations of this acid with these metals are decomposed by tin, which precipitates them, and unites with the acid.

Sulphur may be united with tin by fusion, and forms with it a brittle mass, more difficultly fusible than pure tin.

Sulphur

has in this reſpect the ſame effect upon tin as upon
'he allay of ſulphur leſſens the fuſibility of theſe
ble metals, while it encreaſes the fuſibility of other
y fuſible metals, as of iron and copper.
nay be allayed with all metals by fuſion, and in all
ons; but it abſolutely deſtroys their ductility. A
ble circumſtance is, that the moſt ductile metals, as
l ſilver, are thoſe the ductility of which is moſt
y tin. The vapor of a ſingle grain of tin is capable
ring a conſiderable quantity of gold brittle. The
of copper is leſs injured by tin than that of other
although it is conſiderably injured. A ſingular
ance concerning this allay is, that tin, although a
metal, and not at all ſonorous, augments con-
the ſtiffneſs, the hardneſs, and the ſonorouſneſs
r, as we ſee in *bell-metal.*
llay, or amalgam of tin with mercury, is employed
one of the ſurfaces of looking-glaſſes, by which
rendered capable of reflecting the rays of light,
forming mirrors. This covering of tin and mer-
hich is applied upon glaſſes, is called *tinning.*
allayed with an equal quantity of lead, forms the
ſed by plumbers.
rding to Mr. Gellert's Table, the affinities of tin
n, copper, ſilver, and gold. *See, for the allays of*
words ALLAY, AMALGAM, *and* BRONZE.
is not much uſed in medicine, and for good reaſons:
find, from a long Diſſertation by Margraaf upon
tal, that tin generally contains more or leſs of an
l matter, which probably proceeds from the ores of
all theſe contain arſenic. *See* ORES *and* SMELTING
s. Mr. Margraaf diſcovered this arſenical part of
efly in the humid way, and by ſolution in acids.
ite calx of this metal is commonly employed in the
tion of the *antihectic* of *Poterius*, and of the *lilly of*
ſus: but this calx is unſoluble and ineffectual: be-
t appears to furniſh no part of the lilly.
is very extenſively uſeful in many arts, as we may
rom what has been ſaid of the different preparations
metal.
NNING *of* COPPER, *and of* IRON. Tin-
an operation by which a very thin layer of tin is
to the ſurface of ſome metals, and eſpecially of
and of iron. The methods of tinning theſe two
are different. Copper is tinned after it has been
formed

formed into utenfils, and by the copper-fmiths who form thefe utenfils. The tinning of iron is performed upon thin plates of iron, in particular manufactories in France, in Germany, and in fome other places. Workmen, called *tin-fmiths*, do only form thefe plates, which are brought ready made from their proper manufactories, into the various utenfils required.

The feveral operations for tinning of copper and iron are founded, firft, on the facility with which tin unites with thefe metals, which is fo great, that when either of thefe metals are tinned, the tin only requires to be melted, and the others on which it is to be applied do not. Neverthelefs, the tin incorporates with thefe metals, diffolves in fome meafure their furface, and forms a kind of allay, at leaft when the tinning is well performed.

Secondly, the foundation of all the parts of the operation ufed to make the tinning fucceed is, that metals cannot perfectly unite with each other but when they are in a metallic ftate; and that they cannot unite with any earthy matter, not even with their own earth or calxes.

Hence, the whole art of tinning confifts in applying melted tin, the furface of which fhall be very clean, metallic, and not covered with any afhes or calx of tin, to the furface of iron or of copper, which muft alfo be very clean, and free from all ruft or calx.

To attain thefe purpofes, the following method is ufed. As the furface of copper is continually altered merely by the action of air, the workmen, before the tinning of any veffel, fcrape its furface with a fteel inftrument till it be clean and bright: then they place the veffel upon kindled coals, and heat it to a certain degree: as foon as it is hot, they rub it with pitch; and then apply the melted tin, which they fpread upon the furface of the copper by means of hards. Pure tin is feldom ufed for this purpofe; but generally two parts of tin are allayed with one part of lead.

The pitch ufed in this operation is quite neceffary, becaufe the degree of heat given to the copper is fufficient to calcine its furface in fome meafure; and this alteration, however flight, would prevent the perfect adhefion of the tin, unlefs, by means of the pitch, the phlogifton was reftored to it at the very inftant of the application of the tin. This pitch prevents alfo the flight calcination which would happen on the furface of the tin, or revives the

l particles of calx which are formed during the
.

plates of iron are to be tinned, they must be per-
ll cleansed, which is done by scouring them with
l steeping them some time in acid liquors: then
to be wiped, and dried quickly and perfectly.
hey are to be plunged vertically into a vessel con-
nelted tin, the surface of which is covered with
itch. These fat substances covering the surface of
upply it continually with phlogiston, prevents its
on, by which its adhesion to the iron would be im-
nd also render the surface of the iron, while it passes
them, fitter to receive the tin. By thus plunging
iron into melted tin, they are covered over with
l, or are tinned.

moniac is also used successfully in the tinning of
of copper, and always for the same reason. The
is salt perfectly cleans the surface of the metals to
l, and also the oily matter contained in sal ammo-
ishes the phlogiston that is necessary in this opera-
hus, by heating these metals to a certain degree,
ing them with sal ammoniac, the tin may be ap-
nediately afterwards.

dvantages received from tinning are very consider-
s tin is a soft and fusible metal, vessels formed of
would not have sufficient strength and hardness
heir shape in common use, and would also be liable
lted with a small heat: but when it is applied to
ce of hard and difficultly fusible metals as copper
, many vessels may be fabricated, which have
ntage of being preserved by means of the tin
t, to which the copper and iron are very subject.
een, nevertheless, justly alledged, that copper
e not perfectly prevented from rust or verdigrise
g; and this fault is so much more important, as
pper vessels, are generally used in the preparation
als. These vessels therefore, even when tinned,
t to be employed for this purpose; especially as
is suspected of being hurtful to health, since Mr.
f discovered that arsenic is contained in almost all
also because lead, a most hurtful metal, is used
g. Nevertheless, tinned copper vessels may be
many other purposes. Besides, the tinning of
nd iron vessels may be improved, by attending to
the

the fundamental principles of this art delivered in the prese
article. (*o*)

TINNING *of* LOOKING-GLASSES. Thi
operation consists in applying an amalgam of tin and mer
cury upon one of the surfaces of looking-glasses, by whic
they are rendered much more capable of reflecting the ray
of light, and consequently of representing, in a clear an
lively manner, the images of objects.

This effect of the tinning of looking-glasses is founde
on the superior opacity, and consequently on the superio
reflective power of metallic to all other substances.

Glasses to be tinned are placed upon tables in a perfectl
horizontal or level situation. The surface, previously we
cleaned, is to be covered with tin-leaves, which also mu
be very clean. Upon these is poured a sufficient quantit
of mercury to cover the whole surface, and it is allowed t
rest some time, that it may amalgamate perfectly with th
tin-leaves: then a small degree of inclination is given t
the glass, that the superfluous mercury may run off; whic
inclination must be gradually encreased till the glass be a
last brought to a vertical situation, by which means no mor
mercury remains than is really amalgamated with the tin
As the surface of the glass is exceedingly smooth and wel
polished, the amalgam is in very perfect contact with it
and therefore firmly adheres to it.

The success of this operation depends much on the clean
ness of the surface of the glass; for the least dirt or du
interposed betwixt the amalgam and the surface of the glass
would absolutely prevent the adhesion of contact betwee
these two bodies.

Since vitrified matters, as glasses are, cannot unite in
timately with metallic substances, the adhesion of the amal
gam upon the glasses is not so strong as that of metals upo
metals; as in the tinning of copper and of iron, in whic
there is a solution, a penetration, and an intimate unio
of the tin with the surface of the tinned metal: but in th

(*o*) M. Malouin has proposed, in his Memoirs on Zinc, (Mem.
de l'Acad. des Sciences, 1742) to substitute that semi-metal in
place of lead and tin, for the tinning of iron and copper vessels:
The greater hardness of the zinc, it is thought, would render it les
liable to be worn, and the dangerous effects of lead and tin woul
be avoided. But whether it might not be attended with othe
inconveniences, must be submitted to further experience. *Disc.
prel. Mem. Acad. Berlin* I.

tinnin

of looking-glasses, there is only the adhesion of or a perfect juxtaposition, which may take place any bodies, however heterogeneous, by the appli- their polished surfaces. Accordingly, this me- vering may very easily be taken off, and ought to ved from moisture, and from any kind of rubbing, slight. For which reason, the superfluous mercury made to run off very gently and slowly, otherwise nalgam might fall off by its weight.

CAL. (p)

CTURE. By this name are distinguished, in and pharmacy, all spirituous liquors that are y being digested upon different substances. These erly speaking, infusions in ardent spirits.

chemical preparations are called *tinctures*. We t of some of the chief of these.

CTURE (ALKALINE). *See* TINCTURE *of* TARTAR.

CTURE *of* ANTIMONY. This tincture according to the Paris Dispensatory, in the follow- ner: Let a mixture of one part of crude antimony, parts of the alkaline salt of tartar, be fused in a crucible, and the fusion continued during an The melted matter is to be poured out; and as t has become solid, it is to be pulverised; while yet s to be put into a matrass; and upon this powder spirit of wine is to be poured, to a height above der equal to the breadth of three fingers. This is to be digested with a gentle heat during several which it acquires a deep red color; and then e decanted and preserved in a well-closed bottle.

s fusion of crude antimony with fixed alkali, a sulphur is formed, which dissolves the reguline antimony. It is consequently an antimoniated sulphur, nearly of the same nature as that of which *ineral* is made: but in the present operation this s not dissolved in water, but is digested in spirit

INCAL. Borax, in the crude state in which it is brought a, and before it is refined, is called tincal. It consists crystals, of a yellowish color, and it has a greasy or touch. According to Mr. Cadet, it contains a larger of the peculiar vitrescible earth of borax, than the re- commonly sold does. *See* BORAX, *and* SALT (SEDA-

of

of wine; which menstruum seems to dissolve a part of the whole matter, that is, a part of the liver of sulphur, and by means of it also some of the regulus of antimony; for this tincture acquires a red color, and produces nausea according to Lemery, when taken internally. According to the same author, the dose of this tincture is from four drops to twenty, and is to be administered in some proper liquor.

The medicinal effects of this preparation may be very good, and analogous to those of kermes; but it is not much used. *See* KERMES (MINERAL).

This solubility of antimoniated liver of sulphur in spirit of wine is remarkable: but an explanation of all the appearances that occur in this and in several other operations would require more particular researches than have yet been made.

TINCTURE *of* MARS. Iron, being a metal much employed in medicine, has been prepared in various manners for internal use. Amongst the principal of these are the following tinctures.

TINCTURE *of* MARS (LUDOVICUS's). This tincture is made, according to the Paris Dispensatory in the following manner: Four ounces of martial vitriol calcined to whiteness are to be mixed with an equal quantity of cream of tartar, and this mixture is to be boiled in a pound and a half of water, till the whole has acquired the consistence of honey. This mass is to be put into a matrass, into which some rectified spirit of wine is to be poured to a height equal to the breadth of four fingers. After a digestion during some time in a sand-bath the tincture is to be decanted, and a fresh spirit of wine is to be poured on the residuum, and digested as before. These operations are to be continued as long as the spirit of wine acquires color: and, lastly, all these tinctures are to be mixed together and preserved for use.

The theory of this process is not well known; because all the circumstances have not been examined with sufficient attention. We see, indeed, that the cream of tartar ought to act upon the portion of the iron of the martial vitriol, which does not adhere very strongly to the vitriolic acid, or which is even quite disengaged from that acid by calcination; and that this combination of iron with cream of tartar may be soluble in spirit of wine, to which it may communicate color, and consequently may form the present tincture: but does not the cream of tartar act also upon

iron which is united with the vitriolic acid; and
s not act, does the martial vitriol dissolve in spirit

oes not dissolve in this spirit, when it is single and
inary state, and charged with much iron, may it
ne soluble either when it has deposited a part of
or by means of the acid of tartar? These are
which, I believe, have not been yet examined;
h must be ascertained, before we can know pre-
nature of this tincture of Mars. For its medi-
ues, *see the article* IRON.

CTURE *of* MARS *of* MYNSICHT. This
is made by digesting the martial flowers of sal
c with a sufficient quantity of rectified spirit of
matrass.

of wine dissolves the salt formed by the union of
n the acid of sal ammoniac; but as this spirit can
lve the sal ammoniac itself, it may be charged
rtain quantity of the latter salt in this operation:
n very possible, that by means of this sal ammo-
dissolves a greater quantity of the martial salt than
otherwise do; and reciprocally, that the martial
it in a condition of dissolving a greater quantity
nmoniac; which effects are similar to those pro-
treating in the same manner corrosive sublimate
mmoniac in spirit of wine: but I do not believe
researches have been made to elucidate this sub-
hemists, who have given receipts for most of the
l preparations of this kind of which we now treat,
quently capricious mixtures, the effects of which
not know. These preparations have been con-
by use, although little trouble has been taken to
their nature: but now that chemistry, taken in
nd genuine spirit, has become a science as accurate
rous in some measure as geometry, all these ancient
ought to be scrupulously examined. We should
tainly reject many of these for their unfitness to
the effects expected, and we should know better
es of those which should be judged worthy to be
in use. Probably the tincture of Mars of Myn-
sesses the medicinal qualities of iron dissolved by
cid, and of sal ammoniac.

CTURE *of* MARS (ALKALINE) *of*
L. This preparation, the knowledge of which
s communicated to us, is a solution of iron in fixed
alkali.

alkali. Although this saline substance be capable of acti directly upon iron, and of dissolving it in some measu this combination succeeds much better when the iron be united with the alkali is previously divided by being d solved in an acid, and especially in nitrous acid, as St has shewn.

According to the process of this celebrated chemist, t iron ought to be previously dissolved in nitrous acid, a the solution ought to be as perfectly saturated as possib This saturated solution is to be added at several differe times to a strong solution of vegetable fixed alkali. Ea time that the solution of iron is poured into the alkali liquor, a kind of precipitate or coagulum of a deep r saffron color is instantly formed: but this precipitate d appears soon after, and dissolves entirely in the alkali liquor, to which it communicates a deep-red yellowish colo More of the solution of iron is to be poured into the alk line liquor, till the precipitate is no longer redissolve Lastly, this solution, which is the martial alkaline tin ture of Stahl, is to be filtrated.

We may easily conceive what passes in this process. T alkali, into which the combination of iron with nitro acid is poured, decomposes at first this combination, uniting with the acid, and precipitating the iron. But there is much more alkali than is required to saturate t quantity of acid added, the uncombined portion of alka finding the iron in a very divided state, attacks and di solves it perfectly.

Iron is not the only metal that may be thus dissolved an alkali. Almost every metal is more or less soluble alkalis, as Mr. Margraaf has shewn. *See his Opuscul Chemiques Diss.* III. This celebrated chemist found that n very pure alkalis, but alkalis phlogisticated by calcinati with ox's blood and volatile alkali, were fit for this purpo

This solution of iron in fixed alkali does not always su ceed, and even sometimes fails, when all the circumstanc directed by Stahl have been observed. I have remarke and also Mr. Beaumé, that it succeeds much more co stantly, and almost certainly, when a solution of iron n nearly saturated and very acid is employed; and when t solution has not the reddish-yellow color of rust that sat rated solutions have, but is clear and limpid, or only sligh ly greenish. We were induced to believe, that a sim lar excess of acid was favourable for redissolving other m tallic precipitates from their acid menstruum by means

alkal

d even that with this excefs, the operation can-
d. But Mr. Marges, an intelligent chemift, has
a folution of iron much impregnated, and high
he iron of which might be perfectly diffolved by
li, without heat; and which conftantly formed
l alkaline tincture, either by pouring the folution
ali, or the alkali to the folution; which proves
henomenon depends on the concurrence of feve-
ftances; as on the ftate of the iron in the ni-
, which is known to be very variable; on the
lefs phlogiftication of the alkali; and perhaps
veral other circumftances, which ought to be
examined, before we can form a judgment.
artial alkaline tincture certainly contains an iron
divided, in a faline and perfectly diffolved ftate,
is not united to any acid; and as it alfo poffeffes
ous alkaline character, it may be very ufeful in
where martial and anti-acid remedies are at the
indicated; and thefe cafes are very frequent, as
hyficians well know.
fine faffron of Mars may be feparated from this
either by precipitating the iron by gradually fatu-
alkali with any acid, or by a fpontaneous depo-
ferruginous fediment, which is flowly formed in
e fame manner as in the acid folutions of iron.
only obferve, that the iron which has been thus
by an alkali is very foluble in acids; fo that
to be precipitated by an acid, we muft take care
a drop more than is neceffary for the perfect fa-
f the alkali, otherwife all the precipitate inftant-
ars, and the liquor becomes clear and almoft
See ALKALI *and* IRON.

TURE *of* MARS (TARTARISED).
aration, like the preceding, is called a tincture,
it contains nothing fpirituous, but merely from
olor. It is a folution of iron by the acid of
nd is a true *martial foluble tartar*, as we fhall

ombination is made, according to the Paris dif-
in the following manner. Six ounces of clean
iron and a pound of powdered white tartar are
ed together in an iron veffel; the mixture is to
ned with a fufficient quantity of water to form it
fs, which muft be left undifturbed during 24
t the acid of tartar may begin to act upon the
 iron.

iron. Then fix Paris pints [12 pounds] of pure wat are poured on the mixture, and boiled together during tw hours. From time to time the mixture muft be ftirre during the boiling, and hot water is added to fupply th place of that which is evaporated. The liquor is then be left to fettle, and to be filtrated and evaporated to th confiftence of a liquid fyrup. Laftly, an ounce of fpir of wine is to be added to it, to prevent the folution fro becoming mouldy.

In this operation, the acid of tartar diffolves the iro becomes faturated, and forms with it a neutral falt, whi is not only very foluble in water, but which is even ve deliquefcent: hence this falt cannot be cryftallized, but obtained in the ftate of a liquor, or of an extract, fom times dry and fomtimes foft, according as it has be more or lefs evaporated. The color of this falt is red, brown, and its tafte is the fame as that of all falts t bafes of which are iron, though fomewhat lefs auftere a ftyptic.

The union of the acid of tartar with iron is very we and fuperficial in this combination; and hence this fal very deliquefcent. This deliquefcence is furprizing, co fidering that, as we have remarked elfewhere, the two fu ftances which compofe it have little or no folubility water. From this difficult folubility in water of the co ponent parts of this tartarifed tincture we may conclu that in whatever proportions thefe parts are mixed togeth this tincture muft always be a neutral falt, perfectly nearly faturated: for if any portion of tartar be not co bined with iron, it will remain at the bottom of the veff or upon the filter; and the fame obfervation may be ap ed to the iron that is not combined with the tartar. verthelefs, as pure tartar is foluble in water, and as c fequently a fmall portion of it may remain unfaturate the liquor, it would be proper, if this martial fol tartar be required perfectly neutral, to add more filing iron than are fufficient to faturate all the acid; bec the fuperabundant quantity could not remain in the f tion, and becaufe by this method of employing a l quantity of filings, the operation may be much fhorter whereas it would be very long, if more filings were ployed than is required for the faturation of the ta and if at the fame time all the tartar was required t faturated.

tartarised tincture of Mars has the same medicinal as the other saline and soluble preparations of iron; , as we have said, the least styptic. Accordingly, where martial preparations are indicated, and at the e the styptic quality of iron is apprehended, this the best preparations of iron that can be prescribed. not essentially differ from the infusion of martial See IRON, and TARTAR.

CTURE of METALS, or LILLY of PA-LSUS. This preparation may be made by several ; but as they do not much differ, we shall here easiest and readiest.

parts of martial regulus of antimony, one part of and one part of pure copper, are melted together ible. The allay thus compounded is to be pow-hen cold, and mixed with thrice its weight of nitre. The mixture is to be thrown at different to a red-hot crucible, where it detonates, and is o a violent fire, till the metals be perfectly reduced . The matter is to be taken from the crucible d-hot, and immediately thrown into a heated iron where it is quickly powdered. The powder is to while yet hot, into a matrass, and upon it some spirit of wine is to be poured to a height equal to dth of four fingers. The digestion is continued ome days, or till the spirit of wine has acquired a yellowish-red color. The spirit is to be decanted in a bottle; and is called the *Tincture of Metals*, f *Paracelsus*.

this name *Tincture of Metals*, we find that the spirit was supposed to extract something from the metals h it was digested in this process; perhaps its e rise to this opinion. Nevertheless, as Mr. Baron erves in his Notes on Lemery, if we consider that llic matters are reduced almost to the state of pure y calcination, we shall be convinced that no part can be dissolved by the spirit of wine. Besides, umé, having particularly examined this prepara-as convinced by experiments that no metallic an be separated from it. But although it con-metallic matter, we do not say that it is in-or that it has no other qualities but those of spirit of wine. On the contrary, we know that is alkalised in this operation; and that this alkali, capable of being rendered as caustic by metallic

Q 2 calxes,

calxes, as it is by quicklime, acquires a power of acting singularly and effectually on spirit of wine, which it partly decomposes. This alkali either forms with the spirit of wine, or it separates from this spirit, an oil, with which it combines, and to which it gives color, and a very acid taste. Hence the tincture of metals resembles much the *tincture of salt of tartar*, of which we shall afterwards treat, and like which it has a spirituous, saponaceous, acrid, and alkaline character. Accordingly, it is successfully used when the fibres and vessels require to be excited and animated; as in apoplexies, palsies, dropsies. For the same reason, it is capable of accelerating the motion of the blood, and of encreasing certain secretions and excretions, particularly sweat and urine. The dose of this tincture is from six or twelve drops to forty or even more, and it must be administered in some proper cordial.

TINCTURE *of* GOLD. *See* GOLD (POTABLE).

TINCTURE *of* SALT *of* TARTAR. This tincture is made by pouring some rectified spirit of wine to a height equal to the breadth of three or four fingers, into a heated matrass that contains some hot salt of tartar, which had been previously fused in a crucible and powdered. The matrass is to be closed, and the digestion is to be continued during several days with a gentle heat, or till the spirit of wine has acquired a fine reddish-yellow color.

This preparation is essentially the same as the tincture of metals, as in both these, the fixed alkali acts upon and colors the spirit of wine; with this difference only, that as the alkali of tartar, in its ordinary state, is much less caustic than when it has been calcined with metallic calxes, it therefore acts less quickly and powerfully in the tincture of salt of tartar than in the tincture of metals. Accordingly the former preparation is more deeply colored than the latter. But if in the preparation of the tincture of salt of tartar, an alkali previously rendered caustic by quicklime be employed, the tincture will be as red and active as the tincture of metals; and hence the medicinal qualities of these two tinctures are the same.

TINCTURES *of* VEGETABLE *and* ANIMAL SUBSTANCES. Many medicinal preparations are called tinctures, because they are made by digesting certain vegetable and animal substances in spirit of wine, to which they communicate different colors, according to their nature.

Som

of these tinctures are made with one vegetable, or substance only. These are called *simple tinctures*, y are distinguished by the name of the vegetable or natter employed; such are the tinctures of myrrh, of saffron, of castor, and many others.

s contain a greater or less number of different e and animal substances, which are digested in wine, according to the several receipts. These general name of *compound tinctures*, and are also shed by the names of their particular authors and .

nall not here enter into a detail of these several tinc- ecause they are rather objects of pharmacy than of y; but shall confine ourselves to the following gene- vations.

as vegetables and animals are composed of several es which are not all soluble, or not equally soluble of wine, we cannot consider spirituous tinctures as e extracts of the vegetable and animal substances em- n their preparation.

dly, the principles of these substances upon which wine can act, are volatile essential oils, and others me nature; resins, properly so called; any oils that saponaceous state, and soluble in water by means saline matter; acids; and lastly, several kinds of salts. And the principles which spirit of wine dissolve directly, are sweet oils and oily concretions not volatile nor saline; substances purely gelatinous mmy; earthy matters not saline nor soluble in and lastly, many neutral salts, which are insoluble of wine, the various kinds of which have not yet termined.

dly, many of the vegetable and animal principles essentially unsoluble in spirit of wine, particularly jellies, and neutral salts, are soluble in water.

thly, from the last observation we may perceive, that es drawn from the same vegetable or animal substance ffer considerably, according to the state of dryness substances, and the dephlegmation of the spirit of nployed. For a tincture made from moist plants, h a weak spirit of wine, must contain some gummy ine principles, which could not be contained in a made with the plants perfectly dried, and a spirit perfectly rectified.

 Fifthly,

Fifthly, as many chemical experiments shew that substances naturally unsoluble in any certain menstruum, may be rendered soluble in that menstruum by some other intermediate substance; and as, amongst the vegetable and animal principles, some such intermediate substances may exist; we cannot therefore affirm that spirituous tinctures contain no other of these principles but such as are naturally soluble in spirit of wine; but we rather think that they probably do contain other principles. This subject has not been examined sufficiently to enable us to speak upon it in a less vague and general manner than we now do. *See* ANALYSIS *by* MENSTRUUMS, *and* SPIRIT (ARDENT).

TIN-GLASS. This name is frequently given to the semi-metal bismuth. *See* BISMUTH.

TOBACCO. *(r)*

TOPAZ. *(s)*

TORREFACTION. This name is given to a kind of calcination by which ores are deprived of the volatile mineralising substances, the sulphur and arsenic which they contain. It is also applied to signify the roasting of some pharmaceutical preparations. Thus, for instance, we say *torrefied rhubarb*, &c.

TRAGACANTH (GUM). *See* GUM.

(r) TOBACCO. The leaves of this plant being distilled in a retort, without addition, yield an acrid, empyreumatic, poisonous oil. Tobacco loses its virulence by long coction in water. From an ounce of American tobacco, water extracted four drams and thirty grains; and from an ounce of the same tobacco, spirit of wine extracted one dram and thirty grains. The spirituous extract was stronger than the aqueous. The former had a fine green color; the latter was yellowish-brown. The distilled water and spirit of tobacco have no taste or smell. *Neuman.*

(s) TOPAZ is a precious stone, of a golden color, the fourth in hardness from diamonds. Mr. Pott has made some curious experiments on the Saxon topaz. He found that this stone could not be fused with even eight times its weight of fixed alkali, but that it was vitrifiable by addition of half its weight of borax, or thrice its weight of chalk. It was also fused by calxes of lead or of copper, and fusible spar, but not by nitre.

This stone may be imitated by fusing a mixture of two ounces of powdered rock-crystal with seven ounces of red lead.

POLI. (*t*)
TORIUM. (*u*)
TURATION is an operation which consists in
chanical division of bodies, and is executed by the
ethods, and by the same instruments, that are
d for other divisions of this kind; that is to say,
ars, upon porphyries, and in mills. *See* DIVISION.
ord is generally applied to denote the division that
of several bodies together, to unite them with each
as, for instance, the extinction of mercury in the
n of Ethiops mineral, and others similar.
RBITH MINERAL. This name is given to a
tion of mercury made in the following manner.
mercury is put into a glass-retort, and upon it is
an equal weight of concentrated vitriolic acid, or
ccording to the degree of concentration of this acid.
natters are to be distilled together in a sand-bath till
remains in the retort but a dry saline substance,

RIPOLI is an earth consisting of very fine particles. It
for polishing hard bodies. Tripoli is not fusible in the
s colors are various; grey, yellow, white. It becomes
rd and compact in the fire, as clay does; and from this
probably it has been considered as an argillaceous earth;
t does not appear to have been sufficiently examined. It
imagined to be a powder formed by the decomposition
dering of jasper. Neuman says, that by distilling two
f it, he obtained two scruples of a weak marine acid, and
portion of sal ammoniac; that by distilling a mixture of
h and nitre he obtained aqua-regia; and that of sixty
f Tripoli, one grain was soluble in concentrated vitriolic
o in diluted vitriolic acid, three in spirit of salt, five in
nitre, eleven in aqua regia, and seven grains in caustic
ali.

RITORIUM. A vessel generally made of glass, used for
ation of liquors of different densities, as oil and water.
st diameter is the middle, and it terminates with an aper-
each of the two extremities. The lower extremity, the
of which is very narrow, is dipped into the mixed liquor,
n it is sufficiently filled, the upper orifice is to be stopped
pressing the thumb upon it, by which means the liquor
d will not run out at the lower aperture when the vessel is
om the mixed liquor. When the fluids, of which this
onsists, have perfectly separated according to their respec-
sities, by removing the thumb the heavier fluid will run
the lower extremity, and the separation will be thus

 which

which is a combination of mercury with vitriolic acid. Th union of these two matters cannot be directly effected bu by this process, because the vitriolic acid cannot attac mercury unless it be highly concentrated, and because thi concentration cannot be performed so well in open as i close vessels. *See* CONCENTRATION. Besides, the hea in this operation favours considerably the action of the aci upon the mercury. The acid which passes into the receive during the distillation, is very suffocating and sulphureous which qualities it receives from the phlogiston of the mer cury.

The white saline mass left at the bottom of the reto is to be put into a large vessel, and upon it large quantitie of hot-water are to be poured at several different times This water weakens the acid, takes it from the mercury which is then precipitated towards the bottom of the vess in form of a very shining yellow citron-colored powde This yellow mercurial powder, having been well washe is called *turbith-mineral*, and is a very powerful emetic.

The tartar with which it is washed contains the acid th was united with the mercury; but it also contains a littl mercury, that remains in a saline state, and is soluble i water, by means of the very large quantity of acid.

Most chemists, especially Mr. Rouelle, have believe that a portion of vitriolic acid remains united with the tu bith mineral, but too little to render it soluble in wate On the contrary, Mr. Beaumé, having examined th matter, affirms that turbith mineral contains no acid, whe it has been sufficiently washed; and by frequently boilin this preparation in a large quantity of distilled water, n a vestige of acid will adhere to it. *

Turbith mineral may also be made, by precipitatin mercury from its solution in nitrous acid by means vitriolic acid, or of some vitriolic salt. For this purpo the nitrous acid must be well saturated with mercury for if it contains any unsaturated acid, no turbith mi neral will appear upon adding either vitriolic salts pure vitriolic acid. Hence mistakes may be committe in making experiments to discover the presence of vitrio acid by means of a solution of mercury, as is frequent done.

* The latter experiments of M. *Bayen* prove, that turbith mi neral does contain vitriolic acid.

ught alſo to obſerve, that turbith mineral becomes
only by being deprived of the adhering vitriolic
d that it remains white till it has been waſhed with a
uantity of water; in general, the more perfectly it
ed of acid, the deeper yellow color it acquires.
ith mineral has been formerly celebrated for the
he venereal diſeaſe; but it is now little uſed, becauſe
le mercurial remedies have been diſcovered. *See*
VITRIOLIC), *and* MERCURY.

RPENTINE. *(x)*

TENAG. *(y)*

URPENTINE is a reſinous juice extracted from ſeveral
Sixteen ounces of Venice turpentine being diſtilled with
ielded four ounces and three drams of eſſential oil; and
quantity diſtilled without water, yielded with the heat
er-bath, two ounces only. When turpentine is diſtilled
l with water till it becomes ſolid, it appears yellowiſh;
e proceſs is further continued, it acquires a reddiſh-brown
In the firſt ſtate it is called boiled turpentine, and in the
colophony or common roſin. On diſtilling ſixteen ounces
rt with an open fire encreaſed by degrees, we obtain, firſt,
ces of a limpid colorleſs oil; then two ounces and two
f a thicker yellow oil; and laſtly, two ounces and a dram
k-browniſh red empyreumatic oil, of the conſiſtence of a
and commonly diſtinguiſhed by that name.

ſential oil commonly called *ſpirit of turpentine*, cannot
ſingular difficulty be diſſolved in ſpirit of wine, though
ne itſelf is eaſily ſoluble in that ſpirit. One part of the
be diſſolved in ſeven parts of rectified ſpirit of wine; but
ing a while, the greateſt part of the oil ſeparates and falls
ottom. *Neuman.*

UTENAG. This name is given in India to the ſemi-metal
is alſo ſometimes applied to denote a white metallic com-
rought from China, called alſo *Chineſe copper*, the art of
which is not known in Europe. It is the beſt imitation of
ich has been made. It is very tough, ſtrong, malleable,
eaſily caſt, hammered and poliſhed; and the better kinds
hen well manufactured, are very white, and not more
to tarniſh than ſilver is. Three ingredients of this com-
ay be diſcovered by analyſis, namely, copper, zinc and

VALERIAN. (a)

VENUS is the name of a planet, which chemi[sts] have alſo applied to ſignify copper.

VERDIGRISE. Verdigriſe is copper corroded a[nd] reduced to a very beautiful green ruſt, by a vinous ac[id.] This matter, which is uſeful to painters, is convenien[tly] manufactured at Montpellier; the wines of Languedoc, [of] which that city is the capital, being very proper for this p[re]paration.

The following proceſs for making verdigriſe is deſcrib[ed] by Mr. Monet of the Royal Society of Montpellier, and publiſhed among the Memoirs of the Academy for the ye[ars] 1750 and 1753.

Vine-ſtalks well dried in the ſun are ſteeped during eig[ht] days in ſtrong wine, and afterwards drained. They [are] then put into earthen pots, and upon them wine is pour[ed.] The pots are carefully covered. The wine undergoes t[he] acetous fermentation, which in ſummer is finiſhed in ſeven [or] eight days, but requires a longer time in winter, althou[gh] this operation is always performed in cellars. When t[he] fermentation is ſufficiently advanced, which may be kno[wn] by obſerving the inner ſurface of the lids of the po[ts,] which during the progreſs of the fermentation is co[n]tinually wetted by the moiſture of the riſing vapors, t[he] ſtalks are then to be taken out of the pots. Theſe ſta[lks] are by this method impregnated with the acid of the wi[ne,] and the remaining liquor is but a very weak vinegar. T[he] ſtalks are to be drained during ſome time in baſkets, a[nd] layers of them are to be put into earthen pots with pla[tes] of Swediſh copper, ſo diſpoſed that each plate ſhall reſt up[on] and be covered with layers of ſtalks. The pots are to [be] covered with lids, and the copper is thus expoſed to t[he] action of the vinegar, during three or four days or mo[re,] in which time the plates become covered with verdigr[iſe.] The plates are then to be taken out of the pots, and l[eft] in the cellar three or four days; at the end of which ti[me]

(a) VALERIAN. An ounce of the dry root of valerian yiel[ded] with rectified ſpirit of wine three drams and ſix grains of reſin[ous] extract, and the ſame quantity with water yielded four drams a[nd] twenty-one grains. The diſtilled ſpirit is ſlightly, and [the] diſtilled water is ſtrongly, impregnated with the ſmell of the va[le]rian, but no ſeparable oil is obtained. The moſt active prepa[ra]tion is the ſpirituous extract, which contains all the uſeful ma[tter] of the root. *Neuman.*

t

to be moiſtened with water, or with the weak
bove-mentioned, and left to dry. When this
g and drying of the plates has been thrice re-
he verdigriſe will be found to have conſiderably
in quantity, and it may then be ſcraped off for

ion or eroſion of copper, and conſequently a ver-
nay be prepared by employing ordinary vinegar
wine, as is directed in the above proceſs. But it
t have the unctuoſity of ordinary verdigriſe, which
neceſſary in painting. Good verdigriſe muſt
red by means of a vinous acid, or ſolvent, half
l half ſpirituous. Accordingly, the ſucceſs of
ion depends chiefly on the degree of fermentation
the wine employed has been carried: for this
ion muſt not have been ſo far advanced that
ly vinous or ſpirituous part remained in the

riſe is uſed for painting, as it furniſhes a fine green
hen mixed with oil. It enters alſo as an ingre-
ſeveral plaiſters and ointments. In Chemiſtry,
is uſed for the extraction of radical vinegar;
he preparation of *cryſtals of verdigriſe*, or *of Venus*.
STALS *of* VENUS, COPPER, *and* VINEGAR.

DITER. (*b*)

SELS (CHEMICAL) *and* UTENSILS.

ſhewn at the article LABORATORY, how a che-
oratory ought to be diſpoſed, and the principal

RDITER is a blue pigment obtained by adding chalk
ng to the ſolution of copper in aqua-fortis. It is pre-
efiners of ſilver, who employ for this purpoſe the ſolu-
pper, which they obtain, in the proceſs of parting, by
ng ſilver from aqua-fortis with plates of copper. *See*
. It is ſaid that a fine colored verditer cannot be obtain-
ſolution of copper prepared by diſſolving directly that
qua-fortis; and that the ſilver is neceſſary. We know
ctually made by the refiners only. Dr. Merret ſays that
red in the following manner: A quantity of whitening
a tub, and upon this the ſolution of the copper is
This mixture is to be ſtirred every day for ſome hours
ill the liquor loſes its color. The liquor is then to be
, and more ſolution of copper is to be added. This is
ated till the whitening has acquired the proper color.
to be ſpread on large pieces of chalk, and dried in

utenſils

utensils with which it ought to be furnished. At the arti FURNACES, we have mentioned whatever is essential to known concerning those instruments. Lastly, we ha described under each particular name, the principal ves employed in chemical operations. Nothing therefore mains but to make here a kind of enumeration, useful those who would furnish a laboratory; which enumerat may be considered as a compleat supplement to that wh is given at the article LABORATORY.

The ancient chemists, and especially the alchemi have invented vessels of many various kinds and whimsi shapes, suited to their several operations. But now number and variety of those vessels are much diminish either because modern chemists have not so much tience for such tedious and perplexed operations as alchemists had; or because they have found that th operations can be performed with vessels of a simpler for and less various. Accordingly the vessels required in laboratory are few and simple, which is certainly an adv tage. The chief of these vessels are,

Copper Alembics, with their *refrigeratories*, *worms*, and *ceivers*. *See all these words, and* PLATE I.

Alembics of Glass, of *Stone*, and *Earthen-Ware*, of di rent sizes, with their *receivers*, which are matrasses w longer or shorter necks. *See* PLATE I.

Adopters, which are small receivers with two necks, use of which is to encrease the distance of the receiver fr the distilling vessel and the furnace.

Aludels of Earthen-Ware. *See* PLATE I.

A Balance. *See this word.*

Balloons, which are matrasses with large bellies short necks. They are used as receivers. *See* B LOONS.

Bottles of all kinds and sizes. A great number of thes required in laboratories, to contain the different liqu and substances that are volatile, deliquescent, or corros The most necessary of these are large glass bottles c taining three, four, six pints, or more, of any form, containing those matters that are used in large quanti *Crystal-glass Bottles* with glass stopples, to contain all v tile or corrosive liquors. The small bottles or *Phials* very convenient, and may be used as matrasses in m operations. *See* MATRASS.

Glass Jars are cylindrical vessels useful for contai many dry and not volatile substances. Their mouths gene

closed with cork or with paper. Large jars are
t for the mixing of liquors, for precipitations,
great number of these is required of different

of metal. These are useful for evaporations.
generally of copper; but as this metal is very
e corroded by saline matters, a silver bason is very
t.

, or *Dishes* of glass, of stone-ware, and of crystal-
ich are the best of any. These are used in the
ons of corrosive matter capable of acting upon
Some also are made of crucible-earth, and of
, which are employed for containing the sand
aths.

one. This is a cast-iron vessel of the form of a
ne, to the point of which is fixed a pedestal, that
nd firmly, with its point turned downwards. The
s cone is to receive metallic matters melted with
stances, all which being poured into it, the me-
ts of the mixture sink by their weight to the point
verted cone, and are there collected in form of a
The cone ought to be heated, and greased with
efore the melted matters are poured into it.

. *See that word.*

es are kinds of earthen pots of a cylindrical,
or triangular figure, used for fusions of all kinds.
ght to be covered with lids. *See* POTTERY.

Funnels. These ought to be of various sizes;
ary for small filtrations, and for the pouring of
nto bottles.

oulds are iron vessels of a certain thickness, of the
hollow semi-cylinders, to which a handle is an-
The surface of their semi-cylindrical cavities
be very smooth. They are of various sizes. The
ese vessels is to receive melted metals into their
the form of which is given to the metals, which
called *ingots*. We ought always to heat and to
ese moulds before the melted metal is poured into
See PLATE I. *Fig.* 11.

rs. *See that word.*

sses are long-necked bottles. Some of these have
nd some flat bottoms. Some are shaped like an egg,
nce are called *philosophic eggs*. Matrasses are used
ons and digestions.

Muffles.

Muffles. These vessels, which ought to be made o crucible earth, have the form of a hollow cylinder divide in the direction of its axis, and closed on all sides, except ing its front This vessel represents an oblong arch o vault, the hinder part of which is closed by a semi-circula plane, and the lower part or floor of which is a rectangula plane. It is a little oven that is placed horizontally i essay and enamelling furnaces, so that its open side cor responds with the door of the fire-place of the furnace Under this arched oven small cupels or crucibles are placed and the substances contained are thus exposed to heat withou contact of fuel, smoke, or ashes. *See* FURNACE (ESSAY) PLATE I. *Fig.* 9, and PLATE II. *Fig.* I.

Pelicans. See that word, and PLATE I. *Fig.* 6.

Receivers. See that word, and PLATE I. *and* II.

Circulatory Vessels. Two matrasses are so called, int the largest of which the matter to be operated upon is t be introduced; and the neck of the smaller matrass is t be fitted into the neck of the former, so as to be a kind o stopple to it. The joining is to be closed with a lut suitable to the vapors intended to circulate. By mean of this apparatus, one or more substances may be digeste during a long time without any evaporation, because th vapors which arise are condensed in the small matrass tha serves as a stopple, and continually fall back upon th matter in the great matrass. It is, as we see, a very simpl apparatus, which produces the same effect as the pelican.

Subliming Vessels. This name was formerly given to long-necked matrass, which being covered with a capita formed a kind of alembic. It was employed in the distil lation and rectification of very volatile substances; but sinc we have found that the length of the neck of an alembi is quite useless, these have been quite abandoned. Accord ingly, the true subliming vessels are those that are actuall employed in sublimations. *See* ALEMBICS, ALUDELS, MA TRASS, *and* SUBLIMATION.

VINEGAR. Vinegar is a vegetable spirituous acid produced by the second degree of fermentation, or by tha fermentation which succeeds the spirituous, and is calle the *acid* or *acetous fermentation.*

From this definition it appears, that wine only, or vinou liquors can be changed into true vinegar. Every liquo which has completely undergone the spirituous fermenta tion, is spontaneously and necessarily disposed to the aci fermentation. Accordingly every wine does continuall

ten

come vinegar, and actually is changed into vine-
r or later, according to circumstances; unless
ge be prevented by some obstacle to fermentation.
. Vinegar may therefore be made not only from
apes, but also from cyder, beer, and, in a word,
her wines. But as the wine of grapes is preferable
rpose, we shall describe the method of converting
egar.

gar is produced by a fermentation, its qualities
ich on the method of exciting and of conducting
ntation. The wine which is generally converted
ar, and which for its cheapness is generally em-
r this purpose, is such as has already become
hough the better and the more spirituous the
nd also the more of the vinous spirit that can be
n the vinegar, the better and stronger this will be.
ays, in his *Physica Subterranea*, that having di-
ne in order to convert it into vinegar in a bottle
lly sealed, he found, that although a longer than
ary time was required, the vinegar produced was
nger then when free air is admitted. Mr. Car-
lso affirms, that the strength of vinegar may be
reased by adding some aqua vitæ to the wine be-
exposed to the acetous fermentation.

nt methods are practised by manufacturers for
inegar, who are generally believed to be possessed
secret for that purpose. Nevertheless no more
uisite in the preparation of good vinegar, than to
ood wine, and to conduct the fermentation in the
antageous method; in the same manner as good
only be made from good must, and by a well con-
rmentation. The principal part of these opera-
erformed by nature.

ethod of making vinegar consists in mixing the
e fermented with its dregs, and its tartar, and in
this liquor to a heat of about eighteen or twenty
This fermentation seems to require more heat
spirituous. It also excites more heat and tumult;
ugh it ought to be allowed to proceed briskly, yet
ssary from time to time to check it.

ave describes, in his Elements of Chemistry, the
process, which seems to be well contrived, for
ng of vinegar.

two large oaken vats or hogsheads, and in each of
ce a wooden grate or hurdle, at the distance of a

foot

foot from the bottom. Set the veſſel upright, and on
grate place a moderately cloſe layer of green twigs, or fr
cuttings of the vine. Then fill up the veſſel with the fo
ſtalks of grapes, commonly called the *rape*, to the top of
veſſel, which muſt be left quite open.

Having thus prepared the two veſſels, pour into them
wine to be converted into vinegar, ſo as fill one of th
quite up, and the other but half full. Leave them thus
twenty-four hours, and then fill up the half-filled ve
with liquor from that which is quite full, and which
now in its turn be left only half-full. Four-and-twe
hours afterwards repeat the ſame operation, and thus go
keeping the veſſels alternately full and half-full dur
every twenty-four hours till the vinegar be made. On
ſecond or third day there will ariſe, in the half-filled veſ
a fermentative motion, accompanied with a ſenſible he
which will gradually increaſe from day to day. On
contrary, the fermenting motion is almoſt imperceptibl
the full veſſel; and as the two veſſels are alternately
and half-full, the fermentation is by that means, in ſo
meaſure, interrupted, and is only renewed every other
in each veſſel.

When this motion appears to have entirely ceaſed, e
in the half-filled veſſel, it is a ſign that the fermentatio
finiſhed; and therefore the vinegar is then to be put i
caſks cloſe ſtopped, and kept in a cool place.

A greater or leſs degree of warmth accelerate or che
this, as well as the ſpirituous fermentation. In Franc
is finiſhed in about fifteen days, during the ſummer; bu
the heat of the air be very great, and exceed the twen
fifth degree of Mr. Reaumur's Thermometer, the h
filled veſſel muſt be filled up every twelve hours; bec
if the fermentation be not ſo checked in that time, it
become violent, and the liquor will be ſo heated,
many of the ſpirituous parts, on which the ſtrength
the vinegar depends, will be diſſipated; ſo that noth
will remain, after the fermentation, but a vapid liq
ſour indeed, but effete. The better to prevent the diſſ
tion of the ſpirituous parts, it is a proper and u
precaution to cloſe the mouth of the half-filled veſſel
which the liquor ferments, with a cover made of oak-w
As to the full veſſel, it is always left open, that the
may act freely on the liquor it contains: for it is not li
to the ſame inconveniences, becauſe it ferments but
ſlowly.

Dictionnaire Portatif des Arts et Metiers, another
described, by which a very good vinegar is com-
ade at Paris from the lees of wine. For this
l the wine contained in the lees is pressed out,
nto large casks, the bung-holes of which are left
nese casks are put into a hot place; and if the
on proceeds too fast, it must be checked by
re fresh wine. This process is very similar to the

pearances which accompany the acetous fermen-
mble much those that occur in the spirituous
on. In both fermentations, an intestine motion,
, a hissing noise, and an ebullition, may be per-
There are nevertheless essential differences between
sides that the products of the vinous and acetous
ons differ exceedingly, the heat produced by
is scarcely sensible, while that produced by the
nsiderable. Secondly, we have reason to believe,
apor which exhales from vinegar during fermen-
not noxious, as the vapor of fermenting wine is;
has not been observed to produce such bad effects.
ontrary, as the acid of vinegar more and more
or unfolds itself, it seems to acquire more power
nd retain the inflammable principle, which is
langerous part of these vapors. Lastly, vinegar
leposit tartar as wine does, even although it has
e with wine that had not deposited its tartar.
ediment of vinegar is a viscid, oily, and very
matter. The grape-stalks used in the making of
to promote and increase the fermentation, are
er with this matter during the operation. They
ally washed clean, and carefully preserved, to
ne fermentation of more vinegar; because the acid
h they are soaked acts powerfully as a leaven or
The casks also which have been used for the
n of vinegar are to be cleansed from the above-
viscid matter, and kept for the same use, as they
ed fitter than new casks for the preparation of

he acetous fermentation is finished, the nature and
ter of the liquor that has undergone it are totally
Wine has a taste and smell, partly spirituous,
acid; but in good wine the spirit so much
ver the acid, that the latter is scarcely perceptible.
and smell of vinegar also is partly acid and partly

ſpirituous; but the former quality ſo entirely prevails, t
the latter is almoſt totally concealed.

We cannot form any very clear and diſtinct knowle
of the manner in which Nature performs theſe chan
in fermenting liquors. The properties of wine and vi
gar prove, that the acetous fermentation unfolds in a v
ſingular manner the acid parts of wine, and intima
combines them with the inflammable ſpirit. Hence,
changing wine into vinegar, its ardent ſpirit is ſo cove
by the large quantity of acid, that it is no longer p
ceptible; that it now cannot affect the head and intoxica
and that if it be diſtilled, the firſt liquor that riſes v
a heat leſs than that of boiling water is not an ardent ſp
as when wine is diſtilled, unleſs the vinegar be too n
and the acetous fermentation has not been comple
finiſhed; in which caſe the vinegar yields a little ar
ſpirit: but when old vinegar is diſtilled, the liquor
riſes firſt is a ſlightly acid phlegm, which contains the r
volatile, the moſt odoriferous, and the moſt ſpirituous p
of the vinegar.

The acid of vinegar is employed in many chemical
pharmaceutical preparations, for which not common v
gar, but the acid ſpirituous part of vinegar that is obta
by diſtillation, called *diſtilled vinegar*, is chiefly employ

The proceſs of diſtilling vinegar is very ſimple.
quantity of good ordinary vinegar is put into a large cu
bit or ſtill, which ought to be made of ſtone-ware, and
of metal, as the acid of vinegar is capable of acting u
moſt metals. This cucurbit is ſunk in a deep furn
ſo that five or ſix fingers breadth only near its neck
pears. The neck is to be carefully luted with clay
round the furnace, that the capital may not be he
too much. A capital and a glaſs receiver are then t
fitted, and the diſtillation is to be begun with a very ge
heat. The acid ſpirituous liquor paſſes by drops into
receiver. This liquor is white, tranſparent, penetrat
ſomewhat empyreumatic, and diſengaged from an a
but not ſpirituous ſubſtance, and alſo from an extrac
ſaponaceous matter, both which are contained in ordi
vinegar. Theſe latter ſubſtances remain in the ſtill
the coloring matter, and form together an extremely
extract of vinegar. This reſiduum contains alſo ſome
tar, and by incineration yields much fixed alkali, as
matters belonging to vines, grapes, or wine, do.

uld be much miſtaken if we believed that the
ous portion of the vinegar that riſes in this diſtil-
ſtronger acid than the vinegar itſelf. Vinegar
illed with an intention to concentrate it, but
engage it, as we have ſaid, from its extractive
acid which this part contains is not, properly
inegar, but is oily, not ſpirituous, leſs volatile
ormer, or even than water. Accordingly, the
ed in this diſtillation, when well conducted, is
ious and alſo more watery than the acid of the

have attempted different methods of concen-
illed vinegar. Stahl has taught us the beſt
depriving it of its water without any alteration.
od conſiſts in expoſing it to a cold ſufficiently
freeze its watery part, which is afterwards ſepa-
mps of ice, from the more acid part. Thus
vinegar may be conſiderably concentrated. *See*
TRATION *of* VINEGAR *by* FROST.
of vinegar may be more effectually concentrated
ng it with alkalis, earths, and metals, as any
nay. Thus, by drying perfectly neutral acetous
xed baſes, and afterwards by decompoſing them,
e mere action of the fire, or by means of con-
triolic acid, we obtain the ſtrongeſt acetous acid
produced. This acid is called *radical vinegar*.
of VENUS.
of vinegar diſſolves all ſubſtances upon which
can act, and forms with them neutral ſalts,
ich have particular names, but which all might
etous ſalts.
careous earth this acid forms ſalts that in cryſtal-
into ſilky ramifications and vegetations. Theſe
med from their earthy baſes, *ſalt of chalk*, *ſalt of*
&c.
ed vegetable alkali it forms a very pungent and
eſcent ſalt, called *regenerated tartar*, or *terra*
ri. *See* TERRA FOLIATA.
ed mineral alkali it forms a neutral cryſtallizable

latile alkali it forms *an acetous ammoniacal ſalt*,
of Mindererus.
combinations of the acetous acid with metallic
ave not been yet examined. The combinations
l with lead and with copper are beſt known,

 becauſe

because they furnish several preparations used in pa
ing, and some other arts. This acid united with co
forms *verdigrise* and *crystals of Venus*; and with lead f
cerufs, and *salt or sugar of lead*. *See these several art*
The vinegar in which lead is dissolved is called *vineg*
lead, and is sometimes used as a cosmetic, for repe
cutaneous eruptions. But this cosmetic ought not t
employed but under the direction of a prudent physician
it may occasion a dangerous translation of the morbid
mour to other parts.

Mercury dissolved first by nitrous acid, and afterw
precipitated by fixed alkali, is quickly soluble in vin
with which it forms a mercurial acetous salt. The cry
of this salt are shining silver-like plates, not very solub
water. *See* MERCURY.

Vinegar very much concentrated, as the rectified
of Venus, or radical vinegar, being distilled with equal
of highly rectified spirit of wine, furnishes a liquor w
has all the essential characters of ether, or rather is a
ether, called *acetous ether*. The discovery of this ether
lately made by the Count de Lauraguais. *See* ET
(ACETOUS)

Vinegar being an oily, spirituous, vegetable acid is r
weaker than mineral acids, which are less compoun
Accordingly all acetous neutral salts may be decomp
by any mineral acids, excepting the vitriolic acid v
very much sulphurated, which cannot be considered
pure acid.

According to Mr. Gellert's Table, the affinities o
acetous acid are in the following order: Inflammable p
ciple, zinc, iron, copper, lead, and bismuth. G
silver, tin, and mercury, are marked in this Table as i
pable of uniting with this acid.

Vinegar is very useful, not only in ordinary life a
agreeable seasoning for many kinds of food, but als
medicine, in chemistry, and in several arts.

This acid is in general antiseptic, and is considere
incisive and aperitive. It is used as a vehicle in r
preparations which possess these qualities. Thus *f*
oxymel is a syrup made of honey and vinegar. Such als
oxymel of squills, and several other compound vinegars
the use not only of medicine, but also of the toile
receipts for all which are found in Dispensatories.
very important medicinal virtue has been attributed to v
gar, namely, that of curing the canine madness.

Buc

in a work entitled, *An Hiſtorical Treatiſe of Plants* Lorraine and the Three Biſhopricks*, affirms, that ceſsful trials have aſcertained the efficacy of vine- t the ill effects ariſing from the bite of mad dogs, s given in the quantity of a pound each day, to three doſes; one to be taken in the morning, noon, and the third in the evening. The diſ- this quality of vinegar was made accidentally at Trioul, a province belonging to Venice, by an of that town, who having been ſeized with dneſs, was cured by drinking a glaſs of vinegar , inſtead of ſome medicine that had been prepared

e already mentioned the uſe of vinegar in ſeveral preparations, particularly of ceruſs and of verdi-

GAR (DISTILLED). This is the ſpiritu- f vinegar obtained by diſtillation. *See the preceding*

GAR (RADICAL). *See* SPIRIT *of* VENUS.
GAR *of* LEAD. Is a ſolution of lead or in diſtilled vinegar. *See the articles* LEAD *and*

IFICATION. Vitrification is one of the ous and moſt important operations in chemiſtry. uct of this operation is Glaſs; a matter which, made, is valuable for its great hardneſs, beauty, t tranſparency. Theſe principal and eſſential f glaſs render it very extenſively uſeful in ordinary tural philoſophy, in chemiſtry, and in many arts, y form may be given to glaſs, and all kinds of utenſils may be formed of it, which are capable the moſt powerful corroſives and ſolvents. Glaſs of receiving and preſerving the fineſt poliſh. Its of tranſmitting and refracting the rays of light, ecting theſe rays when one of its ſurfaces is covered tallic coat, render it very uſeful for conſtructing eleſcopes, microſcopes, and all kinds of optical or collecting, ſeparating, and decompoſing the ght; and for exhibiting many wonderful catop- dioptrical appearances and experiments. If to irable properties we add that of imitating the lliant precious ſtones, opake or tranſparent, we y be convinced that perfect glaſs is one of the

R 3 moſt

most beautiful and excellent productions of human in-
dustry.

The art of making glass is dependant on chemistr
all its parts. In its principles it is simple, but exter
in its detail, and difficult in its practice. The exten
this art does not permit us to enter into the particul
or into its several branches. In this article we shall en
your to explain the chemical principles upon which the
depends, and which may direct experimental philosoph
as well as intelligent artists, in their researches to
prove it.

Perfect glass, or the most beautiful factitious crystal
perfectly similar in appearance to the whitest and
transparent natural and vitrifiable stones. The only
sible difference between these natural and artificial
ductions is, that the latter are much less hard and n
fusible than natural crystal, or any other vitrifiable st
In fact, pure glass or artificial crystal is essentially of
same nature as vitrifiable stones; or we may rather
that it is vitrifiable earth itself rendered more fusible
by certain additions, as we shall soon shew.

The most simple and elementary of all earths, called
chemists *vitrifiable earth*, forms the hardest and most tran
rent of all natural bodies, when its integrant parts
united together in a due state of aggregation: but the p
of vitrifiable earth cannot form this aggregation, unless
have been previously so much separated from each ot
that they possess a mobility which enables them to u
together according to their natural tendency: the integ
parts of elementary earth may acquire this mobility by
methods; namely, by the interposition of the parts of wa
or of those of fire.

Almost all the vitrifiable stones that we know, as diamo
rock-crystal, and other hard transparent stones, appea
have been once dispersed in infinitely small molecules thro
much water, from which they have afterwards been
posited, and then have united together and formed the
hard transparent masses which we now see. The regular
uniform crystallization of these precious stones is an evi
proof of this truth.

Possibly some of these stones may have been formed
fire, and by a true fusion. Perhaps even this terres
globe has been once, as Mr. de Buffon thinks, one sp
of melted glass, or one immense diamond, the outer c
of which only has been changed by the elements, w

or parts ſtill remain in their vitrified ſtate *(c)*: ertainly know, that of the two above-mentioned y which pure ſolid maſſes of vitrifiable earth may l, that of the diviſion and elaboration by water practiſed by human art, on account of the many red for the operation.

ſecond method, namely, *fuſion*, the time required is better adapted to the ſhortneſs of our lives, ly might, with a ſufficient degree of heat, melt earth, and all other kinds of earths; ſince theſe, iciently purified, are reduced to the nature of earth; and we might convert theſe earths into cryſtal, or of hard tranſparent ſtones, as perfect tural precious ſtones. In a word, nothing but a ciently intenſe is required to melt any earthy d to convert it into a diamond, as brilliant and as e moſt perfect natural diamonds: but here a great, rto unſurmountable difficulty occurs, namely, to heat ſufficiently intenſe to melt the moſt pure and ifiable earth; for the moſt violent heat that art roduced is inſufficient to melt even many of the mpure earths and ſtones, and is therefore much le of melting that earth, which, becauſe it is the d pureſt, is alſo the moſt unfuſible of all natural *See* EARTH.

we conclude, that although we know by what parts of the pureſt earthy principle may be ſo to form bodies ſimilar to the natural precious we cannot poſſibly put theſe means in execution: cannot artificially produce ſolid maſſes of pure tly ſimilar in all their properties to the natural ſtones, we can however very well imitate theſe natural productions, not in their hardneſs and y, but in their tranſparency and luſtre; that is, oſt obvious and ſtriking qualities, by means of

Buffon conjectures, that the earth, as alſo the other ight have been parts knocked off from the ſun by a ng upon its ſurface; that they received from the im- he comet their progreſſive motion; and alſo, by the f the ſtroke, their motion round their own axes; that was then in a vitrified and fluid ſtate; and that a led from its ſurface by the violent heat, the groſſer hich, being afterwards condenſed, formed water, and ſe remaining ſuſpended formed air.

compositions of glass or factitious crystal. The solut
of this problem is founded on the following principles.

First, pure and elementary earth, which makes the pr
cipal basis of all vitrifications, and therefore called vit
fiable earth, is indeed unfusible with regard to us: but
know, that certain very fusible substances are capable
uniting intimately with this earth, and of communicat
to it some of their fusibility; so that by their means
may reduce it to a perfect fusion.

Secondly, the substances capable of acting upon
earthy principle are the inflammable principle or phlogist
and several saline matters; but we may remark, that
these substances do only act as fluxes by uniting intimat
with the vitrifiable earth, and while they themselves m
part of the glass; and also, as the integrant parts of th
fluxes are not capable of forming either with each other,
with the parts of vitrifiable earth, so strong an adhesion
that which can be formed between the parts of the p
vitrifiable earth; it follows, that all factitious cry
must be much less hard than natural crystals, or other h
stones; since these contain only pure vitrifiable earth.

Thirdly, in consequence of the principle that all co
pound bodies partake of the properties of their compon
parts, factitious crystals ought to partake so much more
the properties of inflammable and saline matters, and ou
to be removed so much more from those of pure vitrifia
stones, as they contain a larger quantity of those matt
Accordingly we find, that the smaller quantity of f
that is contained in glass, the greater hardness, lus
and resemblance to natural stones it has, provided
fusion has been compleat. Thus glass is so much m
perfect, as it possesses more of the properties of vitrifia
earth.

These principles, which are incontestable, being o
understood, are easily applicable to the art of making gla
as we shall shew: since, if we could produce a fire su
ciently intense, and had furnaces and vessels capable of s
taining it, we should make glass equal to the preci
stones; it is therefore evident, that the most import
object in vitrification, is to have furnaces capable of p
ducing the greatest heat, and pots or crucibles capable
resisting, during a long time, this heat, and also the act
of the vitrescent matter that they contain. At the articles
this Dictionary, Clay and Pottery, may be seen wh
are the best earths, or mixtures of earths, for the constru

ti

urnaces, and of pots or crucibles. We shall here eat, that these pots ought to be made entirely of refractory and purest clay, well washed and from all sandy, ferruginous, and pyritous matters, d with a certain proportion of the same clay baked, nded not very finely. The quantity of baked clay ht to be mixed with the crude clay, to prevent from cracking when dried, or when exposed to heat, is not absolutely determined, but varies in glass-houses, according as the crude clay employed or less fat, as it is called: but Mr. D'Antic, of Physic, a very able chemist, and particularly nt about every thing relating to the theory ctice of glass-making, in an excellent Memoir s subject, proposes a very good method of ascer- the quantity of burnt clay that ought to be mixed de clay in the composition for pots and furnaces. thod consists in mixing the burnt and crude clay rent proportions, and in forming cakes of these mixtures, each of which is one inch in thickness, and hes in each of the other two dimensions. When kes have been sufficiently and very slowly dried, exposed to a violent heat, till they become as hard, tract as much in their dimensions as they can, to be then examined; and the cake, which has a diminution of its bulk equal only to an eighteenth made of the best proportions. According to the thor, most clays require that the proportion of the ould be to the fresh as four to five.

ovens and furnaces are different according to the of materials to be vitrified. For experiments ys, we know none better than the melting furnace d at the article FURNACE, and which must be with charcoal. In large works wood or fossil coal , and the furnaces are so constructed that the flame fuel circulates and burns within very intensely. furnaces vary much in different countries and glass- and as a description would not be very intelligible figures, we shall refer the reader to other works in hese several furnaces are described and represented, arly to the French edition of Neri's Art of Making with Notes by Merret and by Kunckel, and to the quoted Memoir of Mr. D'Antic. We shall here in general, that these furnaces are placed under d lofty buildings called *halls*; that they are covered with

with a vaulted roof; and that they have no chimney, b
only lateral openings through which the melted glaſs
drawn from the pots. Under theſe openings is built a ki
of platform or banquette, on which the pots containi
the glaſs ſtand, one of which is oppoſite to each openin
In the middle of the furnace, below the banquette, i
ſpace, a-croſs which iron bars are laid. In this ſpa
which communicates with a large cavity below, called t
aſh-hole, the fuel is placed. In theſe furnaces, whi
have not any chimney, as we have ſaid, the fire is neve
theleſs very intenſe. This intenſe heat is occaſioned
the great capacity of the furnace, by means of which
ſtrong draught of air paſſes continually from the aſh-ho
Beſides, the flame, being vividly agitated by air, a
not being drawn out of the furnace by any chimney, c
culates in every direction within the furnace, and produc
a very violent heat. Moſt glaſs-houſe furnaces have al
hollow towers that communicate with the cavity of t
furnace, and which therefore encreaſe the capacity of t
whole. In theſe the heat is not nearly ſo intenſe as in t
furnace. They are employed to contain the *fritt*, or t
pieces of manufactured glaſs that are to be annealed. Su
is the general diſpoſition of the furnaces of glaſs-houſes.

The good condition of the pots and furnaces is, as we ha
obſerved, the moſt important and eſſential matter to be con
ſidered in the operations of making glaſs. Next to that,
the conſideration of the kinds and proportion of the fluxe
Of theſe we may obſerve two kinds, namely, the inflammab
and the ſaline. As we cannot obtain the pure inflammab
principle, we muſt, when we intend that it ſhould enter in
the compoſition of glaſs, chuſe for this purpoſe ſome of t
earthy ſubſtances with which it is found naturally com
bined; and theſe are particularly metallic earths, which a
beſt adapted for conveying phlogiſton into vitreous com
poſitions: but all theſe earths are not equally fit for th
purpoſe. All metals are compoſed of an earthy matt
intimately combined with a ſufficient quantity of the in
flammable principle to be very fuſible, and, at the ſam
time, very opake. Some of theſe metals, namely, tho
called *perfect*, are unalterable by fire, and cannot be en
tirely, or even partly, deprived of phlogiſton: but as ever
metallic ſubſtance is incapable of uniting with earth
matters, while it retains its metallic ſtate, therefore n
perfect metal can be vitrified. The caſe is different wit
thoſe metallic ſubſtances, the phlogiſton of which may b
burn

or otherwise destroyed. The earths or calxes of
erhaps of all combustible metals, when not perfectly
l of all their phlogiston, are capable of being reduced
reous state, by means of their remaining inflam-
rinciple. As they are not then in a metallic state,
n facilitate the fusion of vitrifiable earths, may
with these an intimate union, and reduce them to
of perfect vitrification: but these phlogisticated
of imperfect metals promote vitrification more or
cording to their particular natures. Some of these,
instance, tin, cannot be without great difficulty
to that precise degree of calcination that is neces-
vitrification; because the heat required for this
deprives them of all their phlogiston, and renders
a high degree refractory. Others, in whatever
they be calcined, either retain too little phlogiston
ufficiently fusible, although they still retain enough
them color; or if they be not calcined so much as to
ir fusibility, they cannot be melted but into opake
so nearly in a metallic state that they cannot be
ntimately with vitrifiable earths. Such, especially,
earths of iron and of copper.

ll metallic earths, that of lead is fittest for vitrifica-
This metal, which contains a large portion of
on, is quickly deprived of so much of it, that it
metallic state, and is easily melted into a transparent
mass; but it has, at the same time, this remark-
operty, that when once it has lost as much phlo-
s is necessary to dispose it to vitrification, its calx
retains as much of it as is necessary to give to it
est degree of vitrescibility; and that it may be sooner
d into vapors by the continued action of a very
fire, than it can be changed into an earth totally
isticated, and consequently refractory, like the
of tin and of regulus of antimony. Besides, the
earth of lead is one of these that retain the least
All these qualities render it preferable to any other
earth for the purposes of vitrification. The earth
uth, which in the above-mentioned properties re-
the earth of lead, may probably be employed with
success: but as the calxes of lead are much more
n than those of bismuth, the use of this semi-metal
nown to manufacturers of glass.

hatever manner the calx of lead has been prepared,
d it be really in a calcined and not in a metallic
state,

ftate, it may be ufed in vitrification. Accordingly, th grey calx, or afhes of lead, mafficot, red-lead, litharg cerufs, and all the precipitates of lead, feparated fro acids by unmetallic intermediate fubftances, being mix with fand or any other vitrifiable ftone, and expofed to fufficient degree of fire do always promote the fufion of the matters, and form with them glaffes more or lefs hard an tranfparent, according to the ftrength of the fire and th proportion of the ingredients.

The earth of lead conftantly retains, as we have fai enough of the inflammable principle to preferve its fufibilit When it is expofed fingly to the fire, it vitrifies with a ve moderate heat. It has more phlogifton than is requifi for its vitrification. The fufibility, fluidity, and activi of this glafs of lead, when pure, are fo great, that it cann be contained in any crucible, all which it eafily pervade: therefore pure glafs of lead is never made. But as th calx of lead has more phlogifton than is required for i own vitrification, it may divide this excefs of inflammab principle with any unmetallic earths with which it is mixe and thus may produce their fufion and perfect vitrificatio The glaffes formed by a mixture of calx of lead with u metallic earths have more confiftence, hardnefs, and le fufibility, than pure glafs of lead. The proportions of ca of lead and of fand employed in thefe kinds of glafs, are fro one part to two of calx of lead, to one of fand, or of grou flints.

We may obferve upon the fubject of glaffes that conta no other flux than phlogifton or metallic earths, of lea or of any other metal, that none of them are perfec white, but are all more or lefs colored; becaufe phlogift is, as chemifts know, the principle of colors. Secondl thefe glaffes have a greater denfity or fpecific gravity th any natural cryftalline ftone, all metallic earths bei heavier than any that are not metallic.

Thirdly, metallic glaffes are generally fomewhat l brittle, are lefs liable to be broken by the alterations heat and cold, and have more of a certain fmoothnefs, c as it were, unctuofity, not eafily to be defcribed, than glaf made altogether of unmetallic earths. Thefe propert can only be attributed to the inflammable principle, pretty confiderable quantity of which is united with the As thefe latter qualities of glafs are valuable, a certain qua tity of calx of lead generally enters into the compofition

m

ne glasses, which are distinguished from ordinary
the name *crystal-glass*.

what we have said concerning the properties of
earths in vitrification we may perceive, that the
alx of lead, or other metallic earth, enters into the
ition of any glass, the more fusible, soft, colored,
ase this glass is; and reciprocally. The colors given
by calxes of lead are shades of yellow.

ne substances are the second kind of fluxes used in
ation: but all these substances are not equally fit for
rpose; not that they are not all very fusible, but for
reasons hereafter to be mentioned.

, neither the pure and disengaged acids, nor volatile
nor ammoniacal salts can be employed as fluxes in
ation, because none of these saline matters is suffi-
fixed. Their volatility is so great, that they may
lly dissipated by fire before they could act in any de-
on vitrifiable earth.

ndly, none of the neutral salts with basis of fixed
containing either vitriolic acid or marine acid, can
oloyed as fluxes in vitrification. This proceeds, not
heir want of fusibility, or of the necessary degree of
but from the union of the acid and the alkali; which
rong, that they cannot act with sufficient force upon
substances, and particularly upon vitrifiable earth.
aline matters fit for vitrification are, *fixed alkalis*, ve-
-and mineral; *nitres* with basis of fixed alkali; *seda-
lt* and *borax*; *fusible salt of urine*, or rather *phosphoric*

all saline matters, fixed alkalis, vegetable and mineral,
st frequently used in vitrification. These alkalis are
with a moderate heat; they are so fixed that they can
during a sufficient time the heat of ordinary vitrifica-
and they act powerfully upon flints, sands, and
vitrifiable stones. The proportion of alkali to sand,
er to make good glass, is, from one to two parts of
rmer ingredient, and two parts of the latter.

re produces in vitrification nearly the same effects as
alkalis, although it be a neutral salt, the alkali and
f which are united together nearly as they are in
on salt, which however does not produce in vitrifi-
similar effects. The remarkable difference in this
t betwixt these two salts, and betwixt the nitre and
triolic salts, must be attributed to the great affinity of
s acid to the inflammable principle; which affinity
is

is so strong, that when nitre is exposed to fire in vessels n perfectly close, the acid quits its alkaline basis to uni with the phlogiston of combustible matters, even thoug these be not sensibly in contact with it. Hence nitre ex posed during a certain time to the action of a strong fir is gradually alkalised, and then becomes capable of dissolvin very effectually vitrifiable earth. This alkalisation is pro duced so much more easily in most vitrifications, that th ingredients employed generally contain some inflammab matter. Common salt cannot be alkalised in this manne because it cannot be decomposed by the contact of inflam mable bodies, and therefore is not used in vitrifications but as vitriolic acid has a strong affinity with phlogiston we might be inclined to think, that vitriolic salts wit basis of fixed alkali, which also are never used in vitrificatio might perhaps be employed along with sand or other vitr fiable matters containing a larger proportion of phlogisto than the ingredients now commonly used do: but I do no know that any sufficiently accurate experiments have bee made on this subject.

Fixed alkalis or nitre cannot be formed into transparen glass by being melted singly; because these salts contain to little of the earthy principle; for they form true glass when they are mixed with a sufficient quantity of this prin ciple, as with sands and other earthy matters: but borax sedative salt, and the fusible salt of urine, may be melte without any earthy addition, into transparent vitreou masses; and hence we may conclude, that these salts contai a larger portion of the earthy principle than nitre or fixe alkali. They nevertheless very powerfully promote th vitrification of other substances. These salts are no employed in the manufacture of large quantities of glass because they are too dear. Borax is sometimes used fo making small quantities of some particular kinds of fin glass.

Arsenic may be enumerated among vitrifying fluxes, a it is fusible and vitrescible singly, and is also capable of pro moting the fusion of vitrifiable earths; for which purpo it is frequently employed as an ingredient in vitreous com positions. As arsenic partakes both of the metallic an saline properties, it probably acts in vitrification both as salt and as a metallic earth. The quantity therefore o arsenic necessary to promote vitrification, is intermediat betwixt the quantities of calx of lead and of saline sub stances that are necessary for that purpose. But we mu

observe

that as arſenic is very volatile, a great part of it
n vapors upon the firſt application of heat, and that
tity remaining is always uncertain. Arſenic cannot
employed as the ſole flux for vitrifiable earth.
ve intend that a certain quantity of this matter
emain in the compoſition of a glaſs, one of the beſt
that can be uſed for this purpoſe, is at the ſame
add nitre to the ingredients of this glaſs; becauſe
ic uniting with the alkaline baſis of the nitre forms
ral arſenical ſalt, in which the arſenic is conſider-
d. But as this neutral arſenical ſalt is eaſily de-
d by contact of phlogiſton, therefore no calx of lead
r ſubſtance containing the inflammable principle
be mixed with arſenic in the compoſition of glaſs.
ound by experience, that this neutral arſenical ſalt
lifficultly manageable in vitrifications, not only for
on now given, but alſo from the property it has of
lly corroding and pervading crucibles and pots;
mixtures I have found that it quitted the vitrifiable
th which it was mixed, and acted upon the crucible,
it penetrated and diſſolved. Theſe experiments
ne to believe, that arſenic has a greater affinity with
an with vitrifiable earths; which I propoſe hereafter
ain further.

Mr. Pott's experiments, chemiſts know, that vitri-
calcareous, and argillaceous earths, each of which
ly unfuſible, do reciprocally promote the fuſion
other, when mixed together nearly in equal pro-
, and expoſed to a very violent heat; and that
eſe mixtures matters perfectly vitrified are formed.
we do not know the cauſe of this ſingular fuſibility,
not determine whether it is produced by a phlogiſtic
ſaline ſubſtance, or perhaps by both.

es that contain no other fluxing ingredient than
ic matters or metallic earths, partake of the pro-
of theſe metallic earths; and alſo glaſſes that contain
ine fluxes partake of the properties of ſalts. The
or ſaline glaſſes, when pure and well proportioned
heavy, leſs denſe, harder, whiter, more brilliant,
rittle, than the glaſſes containing calx of lead: and
containing both ſaline and metallic fluxes do alſo
of the properties of both theſe ſubſtances. In gene-
ſſes too ſaline are ſoft, and eaſily ſuſceptible of altera-
the action of air and water; eſpecially thoſe in
alkalis prevail; which latter glaſſes are alſo liable
to

to be attacked by acids, as we evidently see from the properties of the vitrified matter that is made with an excess of alkali, for the preparation of *liquor of flints*. Glasses containing too much borax and arsenic, although at first very beautiful, do quickly tarnish and become opake when exposed to air.

From what we have said concerning the properties of fluxes, phlogistic or saline, we may know how to adjust the proportions of these to the sand, or powdered flints, for the various kinds of glass. Thus if we require a glass that is dense, fusible, and not saline, one part and a half of red lead or litharge may be mixed with one part of sand, and fused together. If equal parts of sand and of calx of lead be employed, a glass somewhat less dense and harder will be produced.

If a glass be required of very little density, only saline fluxes must be employed. A glass of this kind may be composed of six parts of salt of tartar, or of potash, or of purified soda, mixed with eight parts of sand or of flints; or of four parts of any of the above-mentioned alkalis, mixed with two parts of nitre or of borax, and eight parts of vitrifiable earth. These glasses must be left long in the fire for the reasons hereafter to be mentioned.

When a crystal-glass is required which shall be of an intermediate quality betwixt the metallic and saline glasses, it may be made from a mixture of one part of the above-mentioned salts, one part of calx of lead, and two parts of sand or other vitrifiable earth. By varying the proportions of these ingredients, many different kinds of glasses may be produced, each of which may be good, if the quantity of each of the fluxes employed be proportionable to its vitrifying power. Several good receipts for glass, and factitious crystal, may be found in *Neri*'s *Art of Making Glass with Notes by Merret and Kunckel*, to which work we refer for many interesting particulars. We shall however observe, that the proportions of the fluxes necessary to produce any required kind of glass cannot be precisely ascertained, for the following reasons.

First, the sands, flints, and other stones commonly employed for making of glass, are not all equally fusible. Thus the quartzose sand obtained by washing an earth found near Nevers, known to manufacturers of glass and of pottery by the name of *sand of Nevers*, may be almost entirely melted when exposed to a good vitrifying heat; and by a moderate heat its grains may be considerably rounded

I know ſome other hard ſtones, which in a vio-
are ſtill more fuſible, and convertible into an almoſt
nt glaſs without addition. The fuſibility of theſe
e ſtones is cauſed by ſome unknown heterogeneous
nited with them. Theſe fuſible ſands and ſtones
much leſs quantity of flux to promote their vitri-
than other ſands or vitrifiable ſtones, which are
rer, and therefore more refractory.

lly, although the phlogiſtic and ſaline matters
as fluxes in vitrification are ſufficiently fixed to
he degree of fire neceſſary for the fuſion of glaſs,
nevertheleſs far from being ſo fixed as vitrifiable
The fire neceſſary for the perfect fuſion of glaſs, is
icient to evaporate them entirely. Accordingly,
houſes where the pots are uncovered, a vapor
continually riſes from their ſurface, which is
elſe than the ſaline and phlogiſtic fluxes in a ſtate
ual exhalation. Hence the longer glaſs remains
the fire, the harder and more difficultly fuſible
es, and the more it partakes of the properties of
fiable earth. Accordingly, even when a very hard
quired, ſuch a quantity of flux ought to be added,
at firſt promote a perfect fuſion; and this fuſion
be continued a long time till a conſiderable quantity
x is gradually diſſipated, and till the glaſs has ac-
e requiſite degree of hardneſs, provided that the
fficiently ſtrong to maintain the fuſion notwith-
the loſs of flux. From theſe obſervations it
that we cannot preciſely aſcertain the proportion
vitrifiable earth, unleſs we knew the fuſibility of
o be employed, and the degree of heat which can
in the furnace.

line fluxes, and eſpecially the fixed alkalis em-
vitrification, are generally rendered impure by a
f ſeveral heterogeneous matters, and eſpecially by
lts not vitrifiable, and by a certain quantity of in-
principle. In manufactories of bottles and other
glaſs, the alkalis employed are not previouſly
but are even mixed with the earth of the aſhes of
plants, which earth is alſo much diſpoſed to
on. Accordingly, to make glaſs of this kind,
ixed with common wood-aſhes, ſometimes even
which have been lixiviated, together with ſome
potaſh, ſoda or kelp; and from this mixture a
duſky, not very tranſparent glaſs is produced,

which is preferred in common ſale for wine bottles t clearer and more tranſparent glaſs. But when a fine, whit and very tranſparent glaſs is required, the alkali muſt perfectly purified from all heterogeneous matter, lixiviation and calcination. *See the articles* ALKA (FIXED).

As a too large quantity of the inflammable principle is t chief cauſe of the colors and of the opacity of glaſs, wh a perfect colorleſs and tranſparent glaſs is required, n only the alkalis muſt be deprived of all their ſuperabunda phlogiſton, but alſo the ſands or flints employed muſt purified from any of this principle which they may conta The method uſed for this purpoſe is by mixing toget the due proportions of ſands and ſalts, by expoſing t mixture during a conſiderable time to a red heat, not inte enough to melt it. By this calcination, the phlogiſt of theſe matters is burnt and diſſipated, all color is ſtroyed, and the glaſs produced is alſo more clear and br liant. This firſt mixture of materials of glaſs, when ca cined, is called *the fritt*; and this fritt is uſed in lar manufactories not only for the finer glaſs, but alſo for common brown glaſs; not with an intention to render t latter kind of glaſs colorleſs, but becauſe during, this c cination, the ſalts and earth begin to act upon each oth and to incorporate in a certain degree; by which a gr part of the efferveſcence and ſwelling occaſioned by reaction of theſe matters, which happen when they are once expoſed to a melting heat, are avoided. According when matters not previouſly fritted are employed in ſm experiments, the heat muſt be applied gradually; otherw they ſo ſwell, that frequently the greateſt part of the mixt runs over the crucible.

The due degree of heat is an eſſential point in making glaſs; it ought not only to be very ſtrong, but alſo ma tained during a long time. In great manufactories, glaſs is kept fuſed during ten or twelve hours before it taken out of the pots. Accordingly their glaſs is alw more perfect than that which is haſtily made in ſm quantity in two or three hours. Good glaſs, althou kept in fuſion in a very great heat, is not perfectly liqu It is always ſomewhat thick, and when taken from crucible, it may be drawn out into fine wire or threa which ſhews that it has a certain conſiſtence and a v ſenſible tenacity when it is red-hot. It is not tranſpare while it remains red-hot, not even when it has become p

fec

hard. Another remarkable circumſtance is, that
which is ſo brittle when it is cold and tranſparent, is
uctile when it is ſo heated as to be opake. We might
luced to believe, that the diſengaged fire with which
aſs is filled when it is red-hot, produces upon it the
effect that phlogiſton, or combined fire, produces
netals. The ductility of red-hot glaſs is very uſeful;
its means all imaginable ſhapes may be given to glaſs,
umberleſs veſſels and utenſils may be eaſily formed

ſoon as glaſs-veſſels have received their intended form,
nuſt be cooled very gradually, otherwiſe they would
o ſolidity, and would be of little uſe, as they would
ble to be broken by the ſmalleſt ſtroke, or by a
change of heat and cold. This inconvenience is pre-
in glaſs-houſes by carrying the glaſs veſſels as ſoon
are formed, and while yet red-hot, into an oven too
eated to deſtroy their form, but in which they may be
radually cooled. This is called *annealing* the glaſs.
withſtanding all the care taken in the manufactories
iner kinds of glaſs, as cryſtal-glaſs and plate-glaſs, to
them perfectly good, they are nevertheleſs ſeldom
quite free from faults. The principal faults in glaſs
lors, bubbles, and veins. The colors which gene-
urt glaſs, eſpecially that kind which contains ſaline
are ſhades of green, olive, and blue. Theſe colors
troyed by *mangneſe*, which being added in ſmall
ties, clears the glaſs, and is therefore called by artiſts
of glaſs. This effect of mangneſe cannot eaſily be
ed, for it has the property of tinging glaſs with a
color. Mr. Montamy, in his *Traité des Couleurs
Peinture en Email*, has a very fine and ingenious
t upon this ſubject, which is, that the mangneſe
s the above-mentioned colors, by adding to theſe
le tinge, and by the mixture producing a blackiſh-
color; and that as blackneſs is cauſed merely
abſorption of the rays of light, therefore the
h tinge given to the glaſs by the above mixture of
prevents the reflection of ſo many rays, and thus
the glaſs leſs colored than before. The cauſes of
bles and of the veins in all glaſs, even when moſt
ly prepared, and the methods of preventing theſe
are little known. No reſearches have been made
is ſubject, by any chemiſt excepting by Mr. D'Antic,
experiments are publiſhed in the Memoirs of the Aca-

demy. But however interesting these may be, this mat requires further examination. As the veins of glass, unl they be considerable, are seldom very perceptible in the fin kinds of glass when well compounded, and carefully mad they have therefore been hitherto neglected. Neverthel we ought to inform those who are interested in the progr of arts and sciences, that since the important discovery achromatic telescopes has been made, the correction of t fault in glass deserves attention. We need only info those who would attempt this improvement of glass, that t object-glass of these telescopes is composed of several glas of different degrees of density; and that the effect of t composition of different glasses is (supposing them at t same time to have the due curvatures), that telescopes m be made, which do not exhibit irises when looked throug which are therefore infinitely preferable to ordinary te scopes, and from which astronomy may receive much a vancement.

Some great geometers have determined the density a the curvature that these object-glasses ought to have. B in vain have Euler, Clairaut, and D'Alembert illustrat this part of dioptrics by means of the most sublime theor unless glasses can be made which shall be capable of pr ducing the effects required. No certain and constant m thod is yet known for making crystal glass for this purpo A celebrated English optician, Mr. Dollond, who h himself had a considerable share in the discovery of the new telescopes, does indeed make them very good (*d*). B o

(*d*) The indistinctness of the images seen through comm telescopes proceeds chiefly from this cause, that some of the c lored rays of light are refracted more in passing through glass, any refracting medium, than the others, and do therefore pr duce prismatic colors. The late ingenious Mr. Dollond foun that this difference of refrangibility or dispersion of the color rays, was much greater when the rays passed through some kin of glass, as flint-glass, than through others, as crown-glass. B adding, therefore, to the convex object lens of telescopes (whi was made of crown-glass) a concave lens made of flint-glass, th curvature of which was not sufficient to destroy the whole conve gency of rays of light produced by the convex lens, he counte acted the error proceeding from the dispersion of the colored ra in passing through the convex lens, and, by thus uniting the several rays, formed one distinct image. This power of differen kinds of glass, by which they disperse the colored rays is not pro po

opticians, who procure from England the same glass that is employed by the English opticians, affirm that this glass is very faulty; and that amongst a large quantity, some pieces only can be found fit for the purpose: hence we find that it is not constantly made good in the English glass-houses.

tionable to the density of the glass; although calx of lead added to glass singularly encreases this dispersive power. The author of the Dictionary says, that Mr. Dollond had a great share in this discovery. He was the first person who attempted or who executed this improvement. We may indeed observe, that long before, in the year 1713, Dr. David Gregory, the celebrated Professor of Astronomy at Oxford, did suggest, (in his *Catoptricæ et Dioptricæ Sphericæ Elementa*) that by compounding the object glass of a dioptric telescope of several media of different refractive powers, the image might be rendered more distinct, in the same manner (says he) as it is done by the compounded media of the eyes of animals.

Mr. Zieher of Petersburgh has made experiments which shew, that by encreasing the proportion of red-lead to flints in the composition of glass, he could greatly encrease this dispersive power in proportion to the mean refraction; and that by adding alkaline salts to the mixtures of calx of lead and flints, he could greatly diminish the mean refraction of his compositions without lessening their dispersion. He says he composed a glass much superior to flint-glass, as its dispersive power was much greater relatively to its mean refraction. But this is not the principal difficulty in making glass fit for achromatic telescopes. The flint-glass commonly made in England, with a small proportion more of calx of lead in its composition, would sufficiently answer the purpose of opticians, if that glass could be procured free from veins. But here lies the difficulty that has hitherto obstructed the advantages which we had reason to expect from Mr Dollond's excellent discovery. Unfortunately, this kind of glass is peculiarly subject to small veins, which disturb the rays in their passage, and thereby render the vision confused. This effect is owing to the density of these veins being greater than that of the rest of the glass, as appears from their image received on white paper, when the glass is held between the paper and a candle, or other luminous object. For this image of a vein, thus received, is a line brighter than the rest of the image of the glass, and this bright line is defined by a dark edge on each side. But the bright line evidently shews a convergency of rays, and this convergency can only be effected by the veins being denser than the medium in which they are placed. The reason why flint glass is more subject to veins than any othe[r] glass, is (as I apprehend) because it is composed of materi[als] more different densities.

A certain method therefore of making ſuch a cryſtal gla as is required, ſtill remains to be diſcovered. Two kinds glaſs are required for the object-glaſs of achromatic tel ſcopes. One of theſe is a light cryſtal-glaſs, made wi ſaline fluxes, like the French mirror-glaſs.

Good pieces of this kind of glaſs may be eaſily foun The other kind of glaſs is a denſer cryſtal-glaſs, and ther fore contains ſome calx of lead in its compoſition. Such the Engliſh flint-glaſs. The denſity of this glaſs oug to be ſuch, that a cubic inch ſhall weigh fourteen hundr grains. A perfect glaſs of this kind cannot be obtain without great difficulty. I have been aſſured by ſome int ligent perſons, who have conſidered this ſubject of achr matic teleſcopes, that the qualities eſſentially requiſite this glaſs were, that it ſhould be very tranſparent, and p fectly free from veins, to which it is very liable; and tha ſlight tinge of yellow, and even a few bubbles, were not v injurious. I have made many experiments to obtain cryſtal-glaſs free from veins, but have met with great di culties. The veins are undulated, like thoſe which app when two liquors of different denſities, as water and ſp of wine, are added together, and before they are w mixed. This appearance ſhews, that ſomething ſimi happens in the making of glaſs. I endeavoured to corr this fault by a very careful mixture, and by a compl fuſion. But I confeſs, that although I have expoſed th glaſſes to very violent and long-continued fires, and h ſeveral times pulveriſed and ground them, and repeated fuſion, I have not been able to procure any perfectly from veins. I have been prevented by other neceſſary oc pations from continuing my experiments on this ſubj But although thoſe which I have made, ſufficiently ſhew difficulty of making glaſs of the required denſity, and wh ſhall be perfectly free from veins, this difficulty neverthe does not appear unſurmountable; and I do not doubt that by patiently proſecuting this inquiry, we may arriv the deſired ſucceſs.

We ſhall obſerve, in concluding this article, that ſev cauſes leſſen, or entirely prevent the tranſparency of gl which is one of its moſt neceſſary qualities. As we can melt vitrifiable earth into tranſparent maſſes but by me of fluxes, and a ſufficiently ſtrong and long-continued h therefore when the vitreous mixture contains too l flux, or is expoſed to too little heat, ſome parts of the v fiable earth cannot be entirely fuſed, and therefore in

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ore or lefs, according to their quantity, the tranfparency f the glafs. The fame fault may be perceived in glafs, hen it contains fome earthy matter not fufceptible of the ction of fluxes, as vitrifiable earth is; fuch as, for inftance, oft metallic earths that are too much dephlogifticated, rticularly the earth of tin. Accordingly, thefe earths e employed to make opake or femi-tranfparent glaffes, as amels, artificial opals, and other fuch ftones. Another mark may be made concerning the tranfparency of fome nds of glafs, that is deftructible by a too long expofure violent heat. As all fluxes, phlogiftic or faline, are uch lefs fixed than vitrifiable earth; and as fome fluxes e lefs fixed than others, or lefs capable of becoming fixed being mixed with vitrifiable earth; the caufe therefore the lofs of tranfparency which fome glaffes fuffer by a o violent fire, is, that a part of their flux is diffipated, fo at thefe glaffes are decompofed, and that they contain fo uch earth that the flux is incapable of keeping them comeatly fufed. I have obferved that glaffes formed by a ixture of argillaceous, and gypfeous or calcareous earths, e more liable than any others to this lofs of tranfparency. *e* ALKALI, EARTH, FURNACES, *and feveral other articles lating to vitrification.*

VITRIOL. This name is particularly applied to ree neutral vitriolic falts with metallic bafes. Thefe falts e, 1. The combination of vitriolic acid with iron, called *artial vitriol*, *Englifh vitriol*, *green vitriol*, or *green copperas*. The falt refulting from the union of the fame acid with opper, called *vitriol of copper*, *blue vitriol*, *Cyprian vitriol*, *blue copperas*. 3. The falt compofed of vitriolic acid with inc, called *vitriol of zinc*, *white vitriol*, *white copperas*, and *oflar vitriol*.

We have obferved under the articles *vitriolic acid* and *falts*, at the name *vitriol* ought to be applied to all vitriolic falts ith metallic bafis. Thus, for inftance, the falt compofed f vitriolic acid and gold may be called *vitriol of gold*; and e falt formed by the union of this acid with filver may be alled *vitriol of filver*, or *lunar vitriol*. Perhaps all vitriolic lts might be conveniently comprehended under the general ame *vitriol*. The properties of vitriolic falts are menoned at the articles, ACID (VITRIOLIC), ALKALIS, ARTH (CALCAREOUS), SALTS, SELENITES, GYPSUM, LABASTER, SPAR, SMELTING *of* ORES, *and of the feveral etallic fubftances.*

UMBER. (c)

VOLATILITY. Volatility is a property that ma
bodies have of being reduced into light vapors, which exh
when they are exposed to the action of fire. This qual
is opposed to *fixity*. The cause of it is, the greater or l
dilatability which bodies have when exposed to fire. Pe
haps every body is, rigorously speaking, volatile: but
there are some the volatility of which can be only render
sensible by the action of a fire much more violent than a
which we can produce, we consider these bodies as bei
fixed, or not volatile. *See* FIRE *and* FIXITY.

URINE. As urine is an excrementitious animal liqu
it contains only such principles as are useless or hurtful
the animal economy; and is accordingly found to be n
thing but a lixivium of different saline substances, whi
cannot enter into the composition of an animal body, t
gether with a quantity, not very considerable, of a sapon
ceous, extractive, and very putrescent matter. In ur
we find none of the gelatinous substance that is contain
so copiously in other animal liquors that are not exereme
titious; for this gelatinous substance, as we have said und
the article JELLY, is the principal constituent, nutriti
and reparative part of animal bodies, and could not the
fore, without some considerable fault or disorder in the anim
economy, be rejected with any excrementitious matt
The urine of healthy animals is therefore nothing but
serous saline liquor, that may be entirely evaporated, wit
out shewing any gelatinous matter.

The fresh urine of healthy animals is transparent, a
something yellowish or citron-colored, has a slight smell,
saline nauseous taste, and does not change the color of syr
of violets to a red or to a green: but this liquor var
considerably when the animal economy, and especially t
digestive organs, are disturbed. Accordingly, physicia
carefully observe the urine of their patients; but althou

(c) UMBER. Is a fossil substance, so called from *Ombria*,
ancient name of the dutchy of Spoleto in Italy, whence it w
first obtained. M. le Baron de Hupsel has discovered it to b
fossil wood, filled with a bituminous juice. *Berlin Mem.* 17
This substance is found in two different states, first, as retaini
the form of wood, which it has preserved by means of a bitum
nous matter that has prevented the rotting of the wood; a
secondly, as a powder, like that into which the first kind, t
still retains the form of the wood, easily crumbles

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often receive much affiftance from fuch obfervation,
a dangerous error that quacks lead many ignorant per-
into, to believe, that by the mere infpection of urine
lifeafes may be difcovered. Phyficians, who have paffed
r lives in an attentive obfervation of the figns of difeafes,
too fenfible of the infufficiency of every aid to decide
ainly concerning the nature of many difeafes. But this
ction ought to be a motive to inquire into the various
nges that urine undergoes in different ftates of the body,
e accurately than has been hitherto done, efpecially as
improvements daily made in chemiftry may give us
es of throwing more and more light upon this and other
refting fubjects.

The qualities of urine are very apt to vary confiderably,
n without any very perceptible derangement of the animal
nomy. For inftance, it is fometimes much more copi-
than at other times. This difference of the quantity
rine has been obferved to depend much on the quantity
erfpiration and of fweat that have been exfuded at the
e time; for the nature of thefe fluids is very fimilar to
of urine. Generally, when the urine is in fmall quan-
, it is deeper colored: and reciprocally.

The urine of perfons afflicted with hyfterical and melan-
lical fpafms is frequently copious, limpid, and purely
ery or ferous, without color or fmell. This urine is
ed *crude urine*. The fame perfons do alfo frequently
harge urine in fmall quantity, that is high-colored, that
a ftrong fmell, and that quickly becomes turbid when
ofed to cold. We may obferve, that the fediment
ch renders this urine turbid may be again rediffolved by
e frefh and warm urine, and is therefore of a faline na-
.

Certain odoriferous fubftances, taken internally, as tur-
tine, afparagus, and others, are well known to com-
nicate quickly their fmell to urine, even in perfect health:
I have alfo feen perfons fubject to pains of the head and
bad digeftion, proceeding from a melancholic or hyfteri-
temperament, who difcharged urine, in which I could
lently perceive the fmell of coffee, fpices, onions, fruits,
ts, and even of broth, and other aliments. The urine of
fe perfons was habitually acid, reddened fyrup of violets
blue paper, when it was recent, and efpecially after
ing fruits and roots, or drinking even a very fmall quan-
of wine.

From

From these two latter observations we may perceive, urine depends much on the state of digestion, the f of which may therefore be discovered by examining liquor.

Urine is strongly disposed to putrefaction. In te twelve hours, when the weather is warm, it acqui strong smell; and in great heats, this smell may be perc in five or six hours. The beginning of the putrefac of this liquor may be perceived by a putrid, disagree but not pungent smell. The smell afterwards bec pungent, and discovers a volatile alkali, which is very piously disengaged in the putrefaction of this liquor. though the disagreeable smell that is perceived at fi urine beginning to putrefy has not the pungency of vo alkali, it nevertheless seems to be produced by this salt by mixing any acid with urine in this state, its fetid is immediately destroyed. By the same means also smell of vessels in which urine has been contained ma destroyed. On the contrary, by mixing some fixed a or quicklime with fresh urine, a pungent smell of vo alkali and of putrid urine is instantly produced. As short a time no real putrefaction can happen, we mu tribute the discharge of volatile alkali in this experime a decomposition of a sal ammoniac, which is containe the freshest urine, as we shall soon shew.

If the fresh urine of a healthy person be distilled in vessels, nothing is obtained from it with the heat of bo water, but a pure phlegm with a slightly nauseous This phlegm is generally $\frac{7}{8}$ parts or more of the whole u but the quantity of this and of the other principles of are very various.

As nothing but phlegm is separated at first in this dis tion, when therefore urine is to be analysed, the oper may be accelerated and simplified by evaporating it ove fire in an open vessel. We may then observe, that the phlegm of the urine is evaporated, the remaining li becomes turbid, and deposites a certain quantity of m which is almost entirely earthy. The quantity of earth varies also according to the nature of the urine deserves a particular examination. The observation Mr. Herissant, Physician of the Faculty of Paris, and M ber of the Academy of Sciences, concerning the uri several persons afflicted with diseases in which the bones affected and wasted. *See Memoirs of the Academy for th* 1758; and those also of Mr. Morand, of the same Fac

nd Member of the same Academy, concerning the urine of woman whose bones were entirely softened by the loss of eir earthy matter, which was found to contain a consider-ble quantity of earthy sediment; shew, that the earthy diment of urine, which is first deposited by evaporation, partly at least of the same kind as the earth of bones; nd that in a healthy state, nature throws off, by the urinary assages all the earthy matter that is not required for the ncrease or reparation of the bones. This earthy sediment ppears also in putrid urine.

While the urine evaporates, the remaining part of it cquires a more and more deep brown color, by the approxi-ation of the saponaceous extractive parts which it con-ins. When, by evaporation, it has acquired the con-stence of a clear syrup, or of fresh cream of milk, it ought be put in a cool place, that the several neutral salts which contains may be crystallized. The first crystals that are btained are a particular kind of salt known to chemists by e names, *native* or *essential salt of urine*, *fusible salt of urine*, *hosphoric salt*, and *microcosmic salt*. This salt contains the cid proper for making phosphorus. Some part of this salt as a basis of volatile alkali, and is therefore a kind of am-oniacal salt; and the rest has a basis of fixed alkali. *See* ALT (FUSIBLE) *of* URINE, *and* PHOSPHORUS *of* KUNC-EL. When the urine contains any salts that are more ystallizable or less soluble than the fusible salt, as it fre-uently does, such as selenites, vitriolated tartar, and thers, these are first crystallized, especially if they be in onsiderable quantity. *See* CRYSTALLIZATION.

By alternately evaporating and cooling the liquor, the ther less crystallizable salts, such as common salt, a great uantity of which urine generally contains, may be sepa-ated. In the urine of different animals all the neutral salts re generally found which they have taken, either along ith their aliments or otherwise; because these salts, not eing useful in the composition of animal matters, after aving circulated some time in the blood vessels, are carried ff, unchanged, along with the urine.

After all the neutral salts have been obtained from urine, othing remains but a brown, saponaceous, extractive matter, hich forms a kind of mother-water. This matter yields, ith a naked and graduated fire, a considerable quantity of olatile alkali, both fluid and concrete, together with some etid animal oil. With the utmost violence of fire, a small uantity of phosphorus may also be obtained; and a little

common

common ſalt may be ſeparated from the reſiduous coal. T
phoſphorous is produced by a little fuſible ſalt which
not ſeparated by cryſtallization, but remained, toge
with the above-mentioned ſmall quantity of common
diſſolved in the liquor.

From this analyſis of urine we may perceive, that
compoſed of a large portion of pure water, in which is
ſolved a conſiderable quantity of earthy matter, that fo
the ſediment of urine; of two phoſphoric ſalts, one
which is ammoniacal, and the other has a baſis of f
alkali; of common ſalt; and, laſtly, of a ſaline ſapo
ceous matter, which contains a combined oil. In urine
gelatinous matter nor uncombined oil are found.

Such is the ſtate of our preſent knowledge conce
ing the nature and principles of urine. It certainly
capable of receiving much addition from future inqui
by which medicine might be much improved; but we m
at the ſame time, confeſs, that we cannot receive all
knowledge we wiſh upon this ſubject without very long
laborious operations. The moſt important point to
known is the compoſition and proportions of the ſev
conſtituent parts of urine: but, as we have already
marked, theſe are very variable, according to the ſtate
health or of ſickneſs, to the differences of conſtitutio
aliments, exerciſes, diſeaſes, medicines, and perhaps e
to the variations of the atmoſphere. A knowledge of
differences of the urine in all theſe ſeveral circumſtance
very important, but can only be acquired by a long
zealous obſervation of thoſe phyſicians who are inſtruc
in the ſeveral ſciences relative to their profeſſion.

WAND (DIVINING). The divining wand
an inſtrument, by means of which many perſ
have formerly pretended, and ſome do now pretend, to
cover under what parts of the earth metals, treaſures, o
water, ſalt, &c. lie hid, without digging the grou
They ſay, this diſcovery may be made by a perſon hold
the wand horizontally, and by walking along in pl
where theſe matters are expected; and that when he
rives at a place under which any of the above-mentio
matters lie, the wand will be forcibly inclined towards t
pla

place: but that this experiment ſhould ſucceed, much faith ſeems to be required in the perſon who holds the wand, or rather in the ſpectators. We may eaſily perceive, that the power of this wand is a chimera, which owes its reputation to avarice, to ignorance, and to credulity.

The famous Father Kircher, in his *Mundus Subterraneus*, in which many intereſting particulars are found concerning mines, juſtly derides theſe ſuperſtitious practices, and denies, from his own experience, the truth of the aſſertions concerning them. He ſeems, however, to have ſome faith in ſympathies, and propoſes even new divining wands of his own invention; the effects of which, though more dependant on phyſical cauſes, are not however more certain. He believes, for inſtance, that a wand, one end of which ſhould be made of ſal gem, and the other of wood, being ſuſpended and balanced above a mine of ſalt, would be inclined towards the ground; and he ſupports his opinion by an experiment. This experiment conſiſts in evaporating over the fire a ſolution of ſal gem, below the wand, which is by this means really made to incline. We need not be deeply learned in chemiſtry to diſcover, that the wand would have inclined in the ſame manner, if Father Kircher had evaporated pure water inſtead of a ſolution of ſal gem; becauſe the water would have equally well attached itſelf to the ſaline end of the wand; conſequently this experiment proves nothing.

The ſame author propoſes alſo to diſcover mines of mercury by employing a wand, one end of which is made of gold, and the other of wood, in hopes that the emanations of the mercury would attach themſelves to the gold rather than to the wood, and would make it incline downwards. But this effect certainly cannot be produced unleſs the mercury was evaporating; for which purpoſe two conditions are neceſſary: 1. The mercury muſt be in a native metallic ſtate, and not mineraliſed, as it is in cinnabar; and, 2. It muſt alſo be expoſed to the heat of ſome ſubterranean fire, by which it is volatiliſed and ſublimed, the ordinary heat of the earth being far too little for this purpoſe. This ſecond phyſical or chemical divining wand propoſed by Father Kircher is therefore no better than the former; and probably the ſame judgment may be paſt upon all other wands made upon the ſame principles, and in imitation of theſe. Laſtly, the ſame author poſitively affirms, that he hung and balanced a wand, one half of which was made of alder-tree, and the other half of ſome wood that has no ſympathy

ſympathy with water, over a ſubterranean water, and t
he obſerved the end of the wand, which was made of ald
incline towards the earth.

WATER. Water perfectly pure, (for of ſuch o
we treat in this article) is a tranſparent body, with
color, without ſmell, and without taſte.

Water is very volatile, and ſo very fuſible, that it
conſtantly liquid with a leſs degree of heat than is requi
for vegetation: hence it is generally conſidered as a liqu
But when it is expoſed to a leſs degree of heat, it becon
ſolid, like all other bodies naturally ſolid, which reſu
their ſolidity when they are no longer expoſed to a h
ſufficient to keep them in fuſion.

When water, that is expoſed to a degree of cold ſu
cient to render it ſolid, paſſes from a fluid to a ſolid ſta
this change is called the *congelation* or *freezing of wat*
and the water thus rendered ſolid is called *ice*.

When water is frozen with all the circumſtances neceſſa
for the free arrangement of the integrant particles of bod
(which circumſtances are explained under the article Cr
stallization), it aſſumes determinate and regular forn
M. de Mairan, in his excellent Treatiſe on Ice, has det
mined, that theſe regularly formed maſſes of frozen wa
are like needles croſſing each other, or rather infixed in
each other, ſo as always to form two angles, one of whi
is equal to ſixty degrees, and the other equal to a hundr
and twenty degrees.

This regularity in the congelation or cryſtallization
water ſhews, that it is a body not much compounded. V
ſhall ſoon ſee that it is one of the ſimpleſt of all known bodi

Water is not compreſſible. This truth is aſcertain
by a famous experiment, which conſiſts in including wa
in a hollow ſphere of metal hermetically cloſed, and in e
poſing this ſphere to a very ſtrong compreſſion, by whi
means the water is forced through the pores of this metal
ſphere rather than ſuffer any compreſſion. *(ſ)*

(ſ) The validity of the inferences drawn from this expe
ment, called the *Florentine experiment*, has been juſtly queſtione
An ingenious philoſopher, Mr. Canton, has proved, by expe
ments ſhewn to the Royal Society, that water is actually com
preſſed by the weight of the atmoſphere. The diminution of ſi
that water ſuffers when it paſſes from a greater to a leſs degree
heat, till it begins to freeze, ſufficiently ſhews, that the int
grant parts of this fluid are, like thoſe of all other known ſu
ſtances, capable of approximation.

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The ſpecific gravity of water, compared with that of air, in a temperature intermediate betwixt the greateſt ſummer heats and the greateſt cold of winter, has been determined by the beſt experimental philoſophers to be nearly as 850 to 1; that is to ſay, that any given bulk of water is 850 times heavier than an equal bulk of air.

We have ſaid above, that water is a very volatile body. It is entirely reduced into vapors and diſſipated, when it is expoſed to the fire, and is not confined.

When water is heated in an open veſſel, and is unconfined, it has been obſerved to acquire no more than a certain determinate degree of heat, whatever be the intenſity of the fire to which it is expoſed; which greateſt degree of heat is that which it has when it boils quickly. This degree of heat, and alſo that degree at which water begins to freeze, are fixed and determinate, and are therefore very uſeful in many chemical and phyſical experiments. By means of theſe fixed points of heat, we have been enabled to conſtruct thermometers, which may always be compared one with another; and we have alſo been enabled to apply preciſe and determinate degrees of heat, which are neceſſary in many chemical operations. *See* BATH (WATER).

Some philoſophers have ſaid, that the property which water and ſome other bodies have, of acquiring only a determinate degree of heat, proceeds from the rarefaction cauſed by this degree of heat, by which means the fire penetrates them freely and without any reſiſtance. *See* FIRE. But this opinion is erroneous. The cauſe of this phenomenon evidently is, that water being volatile, is reduced into vapors which are conſtantly exhaled and removed from the fire, the action of which they elude as ſoon as they ſuffer a certain degree of heat, as may be proved by the following conſiderations.

Firſt, none but volatile bodies have this property; bodies abſolutely fixed being capable of acquiring indefinite degrees of heat: hence the more volatile a body is, the leſs heat it can require, and reciprocally; or, to ſpeak geometrically, the degrees of heat which bodies expoſed to the action of fire, and unconfined, can acquire, are inverſely as their volatility, and conſequently directly as their fixity.

Secondly, when water and all volatile bodies are expoſed to the action of fire, and ſo confined that they cannot freely evaporate or elude that action, they are then capable of acquiring a degree of heat that is much more conſiderable,

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is indeterminate, or rather proportionable to the force
which they are confined, and prevented from evaporat

We have an obvious example of this in the effec
Papin's Digester. Water being confined in this vess
that it cannot evaporate, is capable of acquiring a de
of heat much greater than that with which it boils in
air, and even sufficient to make it red-hot.

Besides, it has been observed, that the mere variatio
the weight of the atmosphere makes a greater degre
heat to be requisite for the boiling of water in open ve
at sometimes than at others: for the heavier the ai
the greater heat is required to make it boil.

M. Pærner observes, in his notes to the German edi
of this Dictionary, that the degree of heat which bo
are capable of receiving, is relative to their particular
ture, according as it partakes more or less of the infl
mable principle; and he cites, as an instance, the essen
oil of turpentine, which, although it be more volatile
water, is nevertheless, according to him, capable of
ceiving, by boiling in open vessels, a greater degree of
than that of boiling water. From thence we ought to c
clude, that the determinate degree of heat which bo
can receive, when exposed to heat in open vessels, is
proportionate to their volatility or fixity. In answer to t
I observe, that I much question the truth of the alled
experiment, which, however, I have not made, and wh
is not very easy to make on account of the inflamm
bility of the oil of turpentine, and of the insupport
and dangerous vapors which are exhaled, when a suffic
quantity of this and other essential oils are heated t
certain degree in open vessels. I therefore doubt mu
whether the experiment has been made with due care
attention, and I cannot but consider it as false, becau
is contrary not only to theory, but also to all the analog
experiments which have been made on this subject.

It is true, that all bodies exposed to the same heat,
not with equal ease, and in the same time, become equ
hot. Several good philosophers, as Dr. Franklin and
Buffon, have proved, that metals are more quickly hea
than stones. The disposition to receive heat quickly see
to be a property of substances which contain the princi
of inflammability. Franklin therefore considers these su
stances as conductors of heat; and the oil of turpenti
like other inflammable matters, ought to receive heat *m*
quickly, than liquors which do not contain the inflamma
princip

principle. But we ought not thence to infer, that it can receive *more heat*. The property of receiving much heat, and that of receiving it quickly are very different; but M. Pærner seems not to have attended to this distinction. Thus mercury becomes hot more quickly than sand, but is not capable of receiving so much heat.

Upon this subject we must observe, that when water, or other volatile bodies, are thus exposed to a greater degree of heat than is suited to their volatility, they are in a violent state; and are therefore apt to break any vessels that confine them, with an explosion so much more violent, as they are more strongly compressed, and are exposed to a more violent and more suddenly applied heat.

Hence we may conceive why water exposed to heat, too suddenly to allow it to evaporate, gradually occasions terrible explosions; as, for instance, when water is thrown upon very hot oil, or when a melted and red-hot metal is poured into a moist vessel.

We ought to observe upon the subject of these explosions, that they only happen when the volatile bodies are in an aggregate state, or are combined with other volatile bodies; for the most volatile substances, when combined with fixed bodies, may be exposed to the most violent heat without producing these effects. Thus water, when combined with quicklime, with fixed alkali, and other salts, may be suddenly exposed to a red-heat without danger of explosion.

Water seems to be unalterable and indestructible: at least, no experiment is hitherto known, from which we may infer that water may be decomposed. With whatever substances it may be combined, when separated from these and sufficiently purified, it is always found to be the same as before. When it is distilled singly, or mixed with some other substance, its nature and essential properties still remain unchanged.

Some philosophers, as Boyle, and especially Mr. Margraaf, having very frequently distilled the same water, obtained at each operation a small portion of earth; but the water which was distilled remained always essentially the same. The small quantity of earth separated from the water ought to be considered as extraneous to it. M. Lavoisier has ascertained this important fact by a series of accurate experiments which are related in a Memoir presented to the Academy of Sciences. He obtained at each distillation a small quantity of earth; but he found that it came from the

 vessels,

veffels, as appeared upon examining the weight of thefe fore and after the operations.

The famous experiment of Van Helmont, which fince his time been more carefully repeated by others, which confifts in making trees and plants grow merel means of water, does not prove, as fome have fuppofed, pure water is convertible into earth, falts, oil, and other principles of vegetables; becaufe water not contains a fmall quantity of earth mixed with it, but the air alone is the vehicle of a confiderable quantit thefe principles, or of fuch as are capable of producing t

Water therefore appears to be a body fimple and una able: at leaft chemifts, not having any means of decon fing it, may confider it as fuch. They have accordi claffed it amongft the *elements* or primary principles. ELEMENTS *and* PRINCIPLES.

Many experiments and chemical analyfes fhew, water enters as a principle in the combination of many c pound bodies, fuch as all faline and oily fubftances (*See* S *and* OIL); and confequently that it is a part of all v table and animal matters, and of all the faline part minerals. Several ftones even, in which no faline m appears, as calcareous ftones, contain a certain quantit water, which feems to be in a ftate of combination. EARTH (CALCAREOUS) *and* QUICKLIME. But hith no experiment fhews, that water enters as a principle the combination of *metallic matters*, or even into tha *vitrefcible ftones. See thefe words.*

Water diffolves many bodies. It feems to be capab diffolving a certain quantity of *air*; for all natural v being placed under an exhaufted receiver emits many bubbles; and, according to Mr. Mufchenbroek, the v from which air has been thus feparated, is capable o fuming the fame quantity of air; that is to fay, if a f quantity of air be introduced into this water, it will form a bubble, as it would with water already fatu with air, but incorporates with the water, and entirely appears. But this effect is much more fenfible with n kinds of gas, which have till lately been confounded air. The gas which is expelled by the effervefcen acids and alkalis is one of thofe with which water ch itfelf in greateft quantity. *See* WATERS (MINERAL) GAS.

Water feems alfo capable of diffolving a fmall quanti calcareous earth; for the moft limpid, clear water b

difti

diſtilled, always depoſites ſome part of this earth. Some very limpid ſpring waters contain ſo much calcareous earth, that they depoſit a ſediment which encruſts any bodies that happen to be immerſed in them. Theſe waters become thus impregnated by flowing through large quantities of calcareous earth. Such are the waters of D'Arcueil near Paris, and all thoſe which form incruſtations, petrefactions, and ſtalactites. But it is probable that this ſmall portion of calcareous earth is diſſolved in the water merely by means of the gas contained in this liquid.

Metallic matters, excepting the perfect metals, are acted upon by water, but eſpecially by the vapor of water, together with the concurrence of air. It converts their ſurfaces into ruſt.

But, of all known bodies, *ſaline ſubſtances* are moſt eaſily and copiouſly ſoluble in water. A ſtrong affinity is obſervable between this element and all ſaline ſubſtances; ſo that we may ſay in general, that all ſalts are ſoluble in water; that every body truly ſoluble in water is of a ſaline nature; and that no other body can be diſſolved in water but by means of a ſaline ſubſtance. *See* SALTS.

Spirit of wine, and all ardent ſpirits of the ſame kind, may be diſſolved in water in all proportions. *See* SPIRIT (ARDENT).

The *ſpiritus rector* of vegetable and animal ſubſtances, and moſt of the very thin and very volatile fluids, called *gas*, are ſoluble in water. *See theſe words.*

Ethereal liquors, as vitriolic, nitrous, marine, and acetous *ethers*, are ſoluble in water, but only in certain proportions. *See* ETHER.

Water diſſolves the moſt ſubtle and volatile part of any *oils*, as Mr. Beaumé has obſerved. *See* OILS.

Compounds, formed of any oily matters united with ſaline matters (to which compounds we ought to give the general name of *ſoap*, or *ſaponaceous ſubſtance*) are ſoluble in water, ſo much more eaſily and copiouſly as their ſaline principle is in greater quantity, and more diſengaged or unfolded. *See* SOAP.

Laſtly, water is the proper ſolvent of all *mucilaginous*, *gummy*, and *gelatinous matters*; which matters are compoſed of ſaline, oily, and earthy principles. *See* GUM.

We may eaſily perceive from what has been ſaid concerning the properties of water, that it muſt be very uſeful in many chemical operations: but as it diſſolves ſo many

 bodies,

bodies, and probably even all bodies, it can seldom be f
naturally free from heterogeneous matter, or perfectly
The waters of rivers and of springs, however limpid
may be, always contain a certain quantity of earth, w
is in the intermediate state above-mentioned, betwe
simple interposition of parts, and a true solution, o
means of some gas. The best waters of this kind are
which flow through sands, gritt-stone, and other vitri
matters; because vitrifiable earth is least capable of
attacked by water.

The waters of many springs and rivers contain mo
less of a gypseous or selenitic substance really dissolved
as water is capable of dissolving these matters, and
flows through grounds containing them, it must diss
certain quantity of them, and even as much as satu
it. Waters impregnated with selenites are unfit for
mical operations, for being drank, for dissolving soa
for boiling leguminous vegetables. They are a ki
mineral waters, and are called *crude* or *hard waters.*
these words.

Rain or snow waters, properly collected, that is, i
stormy weather, after it has already rained or snowed
time, in open air, and far from the habitations of men
received in earthen-ware vessels, are the best and the
of all native waters. They are sufficiently pure for
chemical operations, because they have been purified
kind of natural distillation: but for greater exactness
because these waters are not always procurable, di
water is generally employed in chemical operations
WATER (DISTILLED). *(g)*

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(g) Native water is seldom, if ever, found perfectly
The *waters* that *flow within*, or *upon the surface of the*
contain various earthy, saline, metallic, vegetable or anim
ticles, according to the substances over or through whic
pass. *Rain* and *snow waters* are much purer than those,
they also contain whatever floats in the air, or has been e
along with the watery vapors. Mr. Margraaf has very acc
analysed, by gentle distillation, some clear rain and snow
that he had very carefully collected in glass vessels. The
residuums obtained by distilling a hundred measures of rain
each of which contained thirty-six ounces, he distilled an
porated, till no more remained than six or eight ounces of
which was very turbid. From this remainder he obtain
filt

WATERS (AROMATIC). Thoſe are called aromatic waters that are impregnated by diſtillation with the

filtration, a hundred grains of a yellowiſh-white calcareous earth; and the filtrated liquor ſtill contained ſome earthy particles ſuſpended in it. Upon adding ſome drops of a ſolution of ſalt of tartar to this filtrated liquor, he obtained by evaporation a few grains of cryſtals, which had the appearance of nitre and common ſalt. From theſe cryſtals he inferred, that the rain-water contained a ſmall portion of nitrous and marine acids; and from the color of the cryſtals, which was browniſh, he concludes that it alſo contained ſome oil and viſcous particles. He further proved the preſence of marine acid in rain-water by adding a concentrated reſiduum of diſtilled rain to ſolutions of ſilver, mercury, and lead in nitrous acid; from all which ſolutions, precipitates were thereby formed. He diſcovered the earthy, ſaline, mucilaginous and oily principles by expoſing rain-water to the rays of the ſun, during ſome months in a glaſs-veſſel; covered ſo as to exclude the duſt, but not air; by which means, the water underwent a kind of fermentation or putrefaction, and a greeniſh ſlime was formed on the ſides and bottom of the containing veſſel. This fermentation, he found, could not be excited, by treating in the ſame manner the rain-water that had paſſed over in the diſtillation made in order to procure the above-mentioned reſiduums.

M. Margraaf having treated a hundred meaſures of *ſnow-water* in the ſame manner as he had done the rain-water, obtained ſixty grains of a ſimilar white calcareous earth, together with the ſame ſaline, mucilaginous and oily principles, but obſerved that the rain-water contained a larger proportion of the nitrous acid, and the ſnow-water more of the marine acid. Upon a further examination of the calcareous earths obtained from rain and ſnow, he diſcovered that they contained a ferruginous matter.

The *purity of water* may be known by the following marks or properties of pure water.

1. Pure water is lighter than water that is not pure; for not only the ſubſtances uſually diſſolved in water, are heavier than water, but alſo the ſpecific gravity of a ſolution of any of theſe ſubſtances in water, is generally greater than the intermediate ſpecific gravity of the water and of that ſubſtance.

2. Pure water is more fluid than water that is not pure: hence it is ſaid to occaſion a louder ſound when poured from one veſſel into another.

3. It has no color, ſmell, or taſte.

4. It wets more eaſily than the waters containing metallic and earthy ſalts, called *hard waters*, and feels ſofter when touched.

the ſpiritus rector, or odoriferous principle of aroma
matters. *See* WATERS (DISTILLED).

5. Soap, or a ſolution of ſoap in ſpirit of wine, mixes ea and perfectly with it.

6. It is not rendered turbid by adding to it a ſolution of g in aqua regia, or a ſolution of ſilver, or of lead, or of merc in nitrous acid, or a ſolution of ſugar of lead in water.

Boerhaave, the author of this Dictionary, and other chem maintain, that pure water is unalterable; and others, as B chius, Boyle, Wallerius, that it may be decompoſed or reſol into other principles, eſpecially into earth.

Boyle relates, that one ounce of water, diſtilled carefull glaſs-veſſels two hundred times, yielded ſix drams of a wh light, inſipid earth, fixed in the fire, and indiſſoluble in wa Boerhaave attributed the earth obtained by diſtillation of wate duſt floating in laboratories. Other chemiſts have made exp ments to aſcertain the truth of that of Mr. Boyle. Lieden found, that when pure diſtilled water is diſſipated or evapor by throwing it into a red-hot iron ſpoon, he always obta a quantity of earth. Wallerius obtained a ſcruple and a hal fine white earth by triturating during two hours a dram diſtilled water. This earth, he ſays, is ſoluble in acids convertible into a hard maſs by a red-heat, which maſ unſoluble by acids, and is vitrifiable into a white tranſpa glaſs by a more violent heat. He found alſo, that a la quantity of earth is depoſited from boiling water with a ſtr than with a gentle fire. *See the Swediſh Memoirs for the* 1760. Mr. Margraaf has made experiments with his accuſto accuracy, from which it appears, that by diſtillation, and by evaporation with the heat of the ſun, of rain water, purity of which had been previouſly aſcertained by thir diſtillations, he obtained a white, light, ſhining earth. earth could not be vitrified with the heat requiſite for the fu of ordinary glaſs; but by a more violent and longer conti fire it was melted into a yellow-greyiſh maſs. He found, about half of this earth was ſoluble in nitrous acid, and tha other half was not fuſible by fire; but that, by additio half its quantity of ſalt of tartar, it was convertible into a tr parent glaſs. The part of the earth that was diſſolved in nit acid was afterwards precipitated from that acid by vitriolic with which it formed a ſelenites; and hence Mr. Margraaf in that it is a true calcareous earth. He does not determine claſs of earths to which the unſoluble part of the earth thus tained by diſtilling water ought to be referred. Mr. Marg obſerves, that earth is more copiouſly depoſited from w boiling with a ſtrong than with a gentle heat. The quanti

TER (DISTILLED). Moſt natural waters ſome heterogeneous ſubſtances that render them impure;

t he obtained, in one experiment, from ſeventy-two f diſtilled water, by twelve diſtillations, was nine or ten

voiſier however maintains, as is mentioned in the text, earth thus obtained by diſtilling water proceeds from the nployed.

argraaf proved the exiſtence of earth in water by another nt. He put two ounces of diſtilled water into a glaſs inches high, and from one to two inches in diameter, d the mouth with a ſmooth glaſs ſtopper. After the l been agitated up and down in this tube eight days, it rved to be turbid, and upon continuing the agitation ys longer, he obſerved diſtinctly, eſpecially upon ex- e tube to the rays of the ſun, particles of earth floating ter.

is article we ſhall ſubjoin three Tables of different ſhewing what quantity of each ſalt is ſoluble in a given of water; and alſo an account of ſome experiments made ller, to ſhew how much of certain ſalts may be diſſolved quantities of water ſaturated previouſly with other ſalts.

ollowing Table ſhews the quantities of the ſaline ſub- at could be diſſolved in an ounce of water, with the heat Fahrenheit's ſcale, according to experiments made by man. *Inſtit. Chemiæ*, p. 48.

	Grains
iata tartari	470
dlitz	384
lt	324
rtar	240
e ſalt	212
riol	210
	200
da	200
niac	176
ſalt	170
lauber	168
orraine	168
lvius	160
eignette	137
iol	124
triol	80
itre	60
chreſt of Glaſer	40
ed tartar	30

pure; and as water exceedingly pure is required for
chemical operations, it muſt be therefore purified for
pu

Sublimate mercury	—	—
Borax	— —	—
Alum	—	—
Volatile ſalt of amber	—	—
Arſenic	—	—
Crude tartar	—	—
Cream of tartar	—	—

The following Table is copied from Mr. Muſchenbroek.
eight firſt experiments were made by Boerhaave, and the
Muſchenbroek, with a heat of 38°.

Sea-ſalt,	oz. 2.	were diſſolved in	oz. 6. and dr. 3.	of pure wa
Sal gem,	oz. 1.	—	oz. 3. and dr. 2.	—
Sal ammoniac,	oz. 1.	—	oz. 3. and dr. 2.	—
Nitre,	dr. 9.	—	oz. 6.	—
Borax,	dr. 4.	—	oz. 10.	—
Alum,	oz. 1.	—	oz. 14.	—
Epſom ſalt,	oz. 1.	—	oz. 1. and dr. 2.	—
Green vitriol,	dr. 1.½	—	oz. 3.	—
Arſenic,	oz. 1.	—	oz. 30.	—
Blue vitriol,	gr. 50.	—	gr. 850.	—
Salt of hartſhorn,	gr. 50.	—	gr. 765.	—
Sugar of lead,	gr. 50.	—	gr. 595.	—
Salt of tartar,	gr. 50.	—	gr. 85.	—
Glaſs-gall,	gr. 50.	—	oz. 7½.	—
Cream of tartar,	gr. 50.	—	gr. 1000.	of boiling

[Fifty grains of cream of tartar may be diſſolved in 100
of lime-water. *Hiſt. de l'Acad. Royale.* 1732.]

Sugar of milk, dr. 7. were diſſolved in lb. 1. of water
to the 167°.

According to Neuman's experiments, the quantities
ſoluble in an ounce of water are expreſſed in the following
He does not mention the heat employed.

White powdered ſugar, — —	oz. 2.
Brown powdered ſugar, — —	oz. 2.
White or brown ſugar candy, —	dr. 9.
Sal diureticus, — —	oz. 1.
[illegible]ſom ſalt, — — —	oz. 1.
[illegible]dlitz ſalt, — —	dr. 6.
Pure fixed alkali, — —	dr. 6.
[illegible] vitriol, — —	oz. ½.
[illegible] vitriol, — —	oz. ½.
[illegible] — — —	dr. 3.
[illegible]lt, — —	dr. 3.
[illegible] Glauber, — —	dr. 2.

purposes by distillation. Water may be distilled in the following manner:

The

Sal ammoniac,	dr. 2.
Volatile sal ammoniac,	dr. 2.
Potash,	dr. 2.
Blue vitriol,	dr. 2.
Pure nitre,	dr. 1. gr. 10.
Sal prunell,	dr. 1.
Soluble tartar,	dr. 1.
Alum,	scr. 2½
Sal polychrest,	scr. 2.
Arcanum duplicatum,	dr. ½
Vitriolated tartar,	dr. ½.
Sugar of milk,	scr. 1.
Sugar of lead,	scr. 1.
Emetic tartar,	scr. 1.
Borax,	gr. 15.
Salt of sorrel,	gr. 10.
White tartar,	gr. 5.
Crystals of tartar,	gr. 5.

Water, when saturated with one salt, is capable of dissolving a considerable portion of another salt; and when saturated with this also, it may still dissolve a third, a fourth, or more salts. Thus, according to Neuman, four ounces of water, that have been saturated with a dram and a few grains of alum, will still dissolve five drams of nitre, then half an ounce of green vitriol, six drams of common salt, three drams of soluble tartar, and five drams of sugar. In the same manner also, four ounces of water saturated with half an ounce of nitre, will dissolve half an ounce of white vitriol, six drams of common salt, six drams of sal ammoniac, half an ounce of soluble tartar, and after all these, an entire ounce of sugar.

Mr. Eller has published an account of the following experiments concerning the solutions of different salts in the same water. *See Mem. of the Acad. of Berlin for the year* 1750.

In each experiment he employed *eight ounces of distilled water*. He found that this quantity of water, when saturated

With four ounces of nitre, dissolved one ounce, five drams of fixed alkali, and half an ounce of common salt:

With three ounces, one dram, and one scruple of common salt, dissolved three drams of nitre, and five drams of fixed alkali:

With three ounces and a half of fossil salt, dissolved half an ounce of nitre:

With half an ounce of cream of tartar, dissolved half an ounce of Sedlitz salt, and half an ounce of fixed alkali:

With

The pureſt natural water that can be procured, as
water of rain or of ſnow, or of ſprings and rivers that
over ſands, and are very limpid, is to be put into a w
tinned copper alembic, which muſt be very clean, or wh
is only employed for this purpoſe, and the diſtillation i
be promoted with a gentle fire.

The firſt portion of water that paſſes into the rece
ought to be thrown away, becauſe it waſhes the alem
and receiver, and becauſe if the water contained accident
any volatile heterogeneous matters, theſe will riſe with
firſt portion of diſtilled water.

The diſtillation is to be diſcontinued, when two-third
water have nearly paſſed, becauſe what remains in the alem
is loaded with a larger proportion of heterogeneous
ſtances, ſome of which the water might raiſe along wit
in diſtillation. *See* DISTILLATION.

Diſtilled water ought to be put into very clean bot
and ſtopped with glaſs ſtopples.

Water is known to have been ſufficiently purified
diſtillation, when it does not change the color of the t
tures of violets, or of turnſol, and when its limpidity is

With an ounce and a half of vitriolated tartar, diſſolved hal
ounce of fixed alkali:

With three ounces and a half of Glauber's ſalt, diſſolved
drams of nitre, and as much ſugar.

With four ounces of ſoluble tartar, diſſolved half an ounc
pure nitre.

With four ounces of Epſom ſalt, diſſolved half an ounce of
ſugar.

With two ounces and a half of ſal ammoniac, diſſolved five dr
of foſſil ſalt.

With an ounce and a half of volatile ſalt of hartſhorn, diſſo
an ounce of nitre and half an ounce of ſugar.

With four drams and two ſcruples of borax, diſſolved hal
ounce of fixed alkali.

With two ounces and a half of alum, diſſolved ſix drams of c
mon ſalt, and one dram of Epſom ſalt:

With nine ounces and a half of green vitriol, diſſolved an ou
and a half of Sedlitz ſalt, two drams of nitre, and three ounce
refined ſugar:

With nine ounces of blue vitriol, diſſolved an ounce of nitre, t
drams of common ſalt, and an ounce of ſugar:

With four ounces and a half of white vitriol, diſſolved
ounce of refined ſugar.

h

hurt by adding to it solutions of mercury or of silver in nitrous acid.

WATERS (DISTILLED). The *distilled waters of plants*, or of *other matters*, are prepared by distilling water from these substances, and are thus impregnated with such principles as may be raised by distillation, with the heat of boiling water.

If the plants thus exposed to distillation with water, manifestly contain volatile principles, as all those do which have a distinguishing smell, we cannot doubt that their distilled water must be impregnated with their odoriferous principle, or of spiritus rector. These waters are called *aromatic waters*. *See* SPIRITUS RECTOR.

The water that is used in the distillation of all essential oils is found much impregnated with the odoriferous principles of the aromatic plants employed; and consequently it is a good distilled water of these plants.

An opinion seems to have formerly prevailed, that even the plants called *inodorous*, might impregnate water with some of their principles by distillation; for such distilled waters are prescribed in many dispensatories. But lately, these distilled waters have been neglected, and are even considered only as common water. This latter kind of distilled water is sensibly less impregnated with principles than the former. But are we certain that they contain nothing of the principles of the plant? Are those plants, whose smell is not very perceptible, entirely destitute of all odoriferous principle? Could not a person whose sense of smell was very acute and much exercised, distinguish plantain and other herbs commonly called inodorous, from each other by smell, especially if they were previously cut and bruised?

We may also observe, that the manner commonly employed for distilling such waters is not well adapted to procure all the peculiar smell and qualities of the plants employed. The plants are generally put into an alembic, and overwhelmed with a large quantity of common water. The distillation is then promoted; the water is made to boil quickly; and the vessels are seldom even luted. What can be expected from this bad management, but that the spiritus rector of these plants that is in very small quantity, and perhaps exceedingly volatile and fugacious, should be entirely dissipated? or if any of it remains in the water, that it should be disguised and covered by the empyreumatic smell that all these waters have when newly distilled, or by the smell

ſmell which they acquire by time, ſo that they canno[t be] diſtinguiſhed from each other?

But if we follow exactly the excellent method directe[d in] the Paris Diſpenſatory; or if we improve upon this by put[ting] the herbs recent, cut, and bruiſed, into an alembic pla[ced] in a water-bath, without adding water to them, and diſtilling to dryneſs, with a very gentle heat and well l[uted] veſſels; and if we then find that the ſmall quantity of w[ater] thus diſtilled from plants, called inodorous, has no ſmell [nor] taſte, and gives all the chemical proofs of pure water, [we] may then juſtly conſider theſe waters as deſtitute of an[y of] the principles and virtues of the plants employed.

Waters called ſimply *diſtilled waters*, are underſtood t[o be] thoſe that are prepared with common water. But as ſ[pirit] of wine is alſo frequently impregnated with the odorife[rous] principle of plants and other ſubſtances by diſtillation, [and] as theſe alſo have been called *waters*, they ought to be di[stin]guiſhed by the name, *aromatic ſpirituous waters*. Such [are] the *ſprituous water of Lavender*, the *ſpirituous water of th[yme]*, &c. Theſe ſpirituous waters are alſo ſometimes ca[lled] *ſpirits*, as *ſpirit of thyme*, *ſpirit of citrons*, &c.

Aromatic ſpirituous waters are impregnated with [the] ſmell of one ſubſtance only, or of ſeveral ſubſtances. [The] former are called *ſimple*, and the latter *compound*.

Many of theſe waters are prepared for the uſes of m[edi]cine, of the toilette, and of the table. The preparatio[n of] theſe waters requires only the uſual attentions to be g[iven] to all diſtillations. Whatever relates to this ſubject [may] be found in *Mr. Beaumé*'s *Elements of Pharmacy*. We [may] there ſee that the ſtrength and agreeable flavor of theſe wa[ters] chiefly depend on the ſtrength of the ſpirit of wine emplo[yed] and eſpecially on its purity from any oil of wine, w[hich] gives the diſagreeable ſmell and taſte of common aqua-v[itæ]. *See* SPIRIT (ARDENT).

WATERS (HARD *or* CRUDE). Theſe na[mes] are applied to all waters that contain any ſenſible quanti[ty of] earth or ſelenites. *See* WATERS (MINERAL). (*g*)

WAT

(*g*) *Hard waters* are thoſe in which ſoap does not diſſolve [uni]formly, but is curdled. The diſſolving power of hard wa[ter is] leſs than that of *ſoft*; and hence its unfitneſs for bleaching, [wash]ing, boiling leguminous vegetables, and for many other pur[poses] of economy and arts. One cauſe of the hardneſs of water is, [that] it contains ſome ſalt that may be decompoſed by ſoap, the a[cid]

WATER (LIME). Lime water is ordinary water in which quicklime has been ſlaked.

Water in which quicklime has been ſlaked, or with which ſlaked quicklime is waſhed, diſſolves the part of the quicklime that is moſt attenuated, and moſt deprived of gas: this ſubſtance, which may be conſidered as ſaline and earthy, communicates to water an alkaline, and ſomewhat acrid taſte. The effects of lime water in chemical mixtures are ſimilar to thoſe produced by quicklime. *See* QUICK-LIME.

Although lime-water contains no volatile principle, it ought nevertheleſs to be preſerved in full and well cloſed

of which uniting with the acid of the ſalt, the oil of the ſoap ſeparates, and the ſoap is ſaid to be curdled. Hardneſs of water proceeding from this cauſe may be diſcovered and cured by adding ſome drops of a ſolution of fixed alkali. The ſalts capable of rendering water hard, are not only ſelenites, which is a very frequent cauſe of the hardneſs of water, but any other earthy or metallic ſalt that may be contained in the water, as all theſe are capable of being decompoſed by fixed alkali. Such are the marine ſalt with baſis of magneſia, or of calcareous earth, vitriolic ſalt with baſis of magneſia called Epſom ſalt, green vitriol, and a nitrous ſalt with earthy baſis, to which Dr. Home attributes the hardneſs of ſeveral waters examined by him. The hardneſs of water has been by ſome perſons attributed to common ſalt. But Dr. Home in his *Eſſay on Bleaching* has ſhewn, that neither pure common ſalt, nor any other ſalt with baſis of fixed alkali, give any hardneſs to water, but that this quality may be given to water by the common ſalt which is generally ſold, becauſe this contains ſome part of the earthy ſalts of ſea-water, or of the water of ſalt-ſprings.

The gas which waters frequently contain, is another cauſe of the hardneſs of water. This gas unites with the alkali of ſoap, renders it mild, and thus weakens its union with the oil. *See* GAS *and* ALKALI (FIXED). This gas, by expoſure of the water during ſome time in open veſſels, exhales; by which means, water is rendered ſoft, and any calcareous earth or iron which may be diſſolved in the water merely by means of the gas, as Mr. Cavendiſh and Mr. Lane have ſhewn, [*Philoſ. Tranſ.* 1767 & 1769.] are precipitated.

By boiling, the hardneſs of water proceeding from gas may be cured, but that from earthy or metallic ſalts cannot.

Spring-waters are frequently hard. River water is generally ſoft. The ſmall quantity of earthy ſalts contained in rain and ſnow waters, according to Mr. Margraaf's analyſis, does not ſenſibly render them hard.

bottles:

bottles: otherwise the saline earthy matter dissolved in to which it owes all its peculiar properties, would be sep rated from it, in proportion as the water should be evap rated, and would appear on the surface in form of a cru called *cream of lime*. The quantity of calcareous mat that is thus separated from lime-water, is even greater th it ought to be, if it was exactly proportionate to the evap ration of the water. The cause of which is, that the quic lime gradually recovers from the air as much gas as necessary to deprive it of its properties of quicklime, and restore it to its state of simple calcareous earth, mild, effe vescing, and unsoluble in water. Hence lime-water, long exposure to air, loses much of its strength, and at l becomes almost insipid. *See a note subjoined to the arti* QUICKLIME.

WATER (MERCURIAL). This name is giv to a solution of mercury in nitrous acid, diluted with greater or less quantity of common water.

This liquor produces very good effects, as an escharot and even as a caustic in some diseases of the skin that a external, local, and especially venereal. Some persons u this mercurial water internally; but as it must be a dange ous remedy, it ought not to be employed.

WATERS (MINERAL). All waters natura impregnated with any heterogeneous matter which they ha dissolved within the earth may be called *mineral waters*, the most general and extensive meaning of that name: which are therefore comprehended almost all those that flo within, or upon the surface of the earth: for almost these contain some earth or selenites. But waters contai ing only earth or selenites are not generally called *miner* but *hard* or *crude waters*.

The hard waters, which are simply selenitic, when tri by the chemical proofs hereafter to be mentioned for d covering the nature of mineral waters, shew no marks of acid or of an alkali, nor of any volatile, sulphureous, metallic matters. Waters which contain a disengaged ca careous earth, change the color of syrup of violets to a gree and those that contain selenites, being mixed with a soluti of mercury in nitrous acids form a turbith mineral; a when a fixed alkali is added, they are rendered turbid, and white sediment is precipitated. These waters also do n dissolve soap well. From these we may know, that a water which produces these effects is a hard, earthy, or sel nitic water. The waters impregnated with gas are also har

Althou

Although the waters of the ſea, and ſaline ſprings, be not generally enumerated amongſt mineral waters, they might nevertheleſs be juſtly conſidered as ſuch. For beſides earthy and ſelenitic matters, they alſo contain a large quantity of mineral ſalts. We ſhall therefore conſider them as ſuch in this article.

Mineral waters, properly ſo called, are thoſe in which gas, or ſulphureous, ſaline or metallic ſubſtances are diſcovered by chemical trials. As many of theſe waters are employed ſucceſsfully in Medicine, they are alſo called *medicinal waters*.

Mineral waters receive their peculiar principles by paſſing through earths containing ſalts, or pyritous ſubſtances that are in a ſtate of decompoſition. *See* PYRITES.

Some of theſe waters are valuable from the quantity of uſeful ſalts which they contain, particularly of common ſalt, great quantities of which are obtained from theſe waters; and others are chiefly valued for their medicinal qualities.

The former kind of mineral waters is an object of manufacture, and from them is chiefly extracted that ſalt only which is moſt valuable in commerce. *See* WATER *of the* SEA; *and* WATER *of* SALINE SPRINGS.

But the nature and proportion of all the principles of which medicinal waters conſiſt, ought to be carefully examined. Many of theſe waters have been accurately analyſed by able chemiſts and phyſicians.

But notwithſtanding theſe attempts, we are far from having all the certainty and knowledge that might be deſired on this important ſubject; for this kind of analyſis is perhaps the moſt difficult of any in chemiſtry.

Almoſt all mineral waters contain ſeveral different ſubſtances, which being united with water may form with each other numberleſs compounds. Frequently ſome of the principles of mineral waters are in ſo ſmall quantity, that they can ſcarcely be perceived; although they may have ſome influence on the virtues of the water, and alſo on the other principles contained in the water.

The chemical operations uſed in the analyſis of mineral waters, may ſometimes occaſion eſſential changes in the ſubſtances that are to be diſcovered. And alſo, theſe waters are capable of ſuffering very conſiderable changes by motion, by reſt, and by expoſure to air.

Probably alſo the variations of the atmoſphere, ſubterranean changes, ſome ſecret junction of a new ſpring of mineral

mineral or of pure water; laſtly, the exhauſtion of minerals whence waters receive their peculiar princi are cauſes which may occaſionally change the qualit mineral waters.

We need not therefore wonder, that the reſults of ana of the ſame mineral waters made by different chem whoſe ſkill and accuracy are not queſtioned, ſhould be different.

The conſequences of what we have ſaid on this ſu are, that the examination of mineral waters is a very diff taſk; that it ought not to be attempted but by profe and experienced chemiſts; that it requires frequent re tions, and at different times; and laſtly, that no f general rules can be given concerning theſe analyſes.

As this matter cannot be thoroughly explained wit entering into details connected with all the parts of chemi we ſhall here mention only the principal reſults, and moſt eſſential rules that have been indicated by the atte hitherto made on this ſubject.

We may admit the diviſion or arrangement of mi waters into certain claſſes, propoſed by ſome of the beſt miſts and naturaliſts.

Some of theſe waters are called *cold*, becauſe they are naturally hotter than the atmoſphere. Some of them even colder, eſpecially in ſummer.

Thoſe are called *hot mineral waters*, which in all ſea are hotter than the air. Theſe are of various degrees of h and ſome of them are almoſt as hot as boiling water. ſome mineral waters certain volatile ſpirituous and el principles may be perceived, by a very ſenſible piq taſte; this principle is called the *gas*, or the *ſpiri waters*.

The waters which contain this principle are gene lighter than pure water. They ſparkle and emit bub at their ſpring, but eſpecially when they are ſhook, poured from one veſſel into another. They ſometimes b the bottles containing them, when theſe are well corke fermenting wines ſometimes do. When mixed with ordi wine, they give to it the piquancy and ſparkling qualit Champaigne wine.

This volatile principle, and all the properties of the w dependant upon it, are loſt merely by expoſure to air o agitation. The waters containing this principle are di guiſhed by the name of *ſpirituous mineral waters*, or *ac lous waters*.

C

Other divisions of mineral waters may be made, relatively to some of their predominant principles. Hence some waters are called *acidulous*, *alkaline*, *martial*, *neutral*, &c.

When a mineral water is to be examined, we may observe the following rules:

Experiments ought to be made near the spring, if possible.

The situation of the spring, the nature of the soil, and the neighbouring rising grounds ought to be examined.

Its sensible qualities, as its smell, taste, color, are to be observed.

Its specific gravity and heat are to be ascertained by the hydrostatical balance and the thermometer.

From the properties above-mentioned of spirituous mineral waters, we may discover whether it be one of this class. For greater certainty we may make the following trial. Let the neck of a wet bladder be tied to the neck of a bottle containing some of this water. By shaking the water, any *gas* that it may contain will be disengaged, and will swell the bladder. If the neck of the bladder be then tyed with a string above the bottle, and be cut below this string, so as to separate the bladder from the bottle, the quantity and nature of the contained *gas* may be further examined.

Lastly, we must observe the changes that are spontaneously produced upon the water in close and in open vessels, and with different degrees of heat. If by these means any matter be crystallized or deposited, it must be set apart for further examination.

These preliminary experiments and observations will almost certainly indicate, more or less sensibly, something concerning the nature of the water, and will point out the method to be followed in our further inquiry.

We must then proceed to the decomposition of the water either without addition and merely by evaporation and distillation, or with the addition of other substances, by means of which the matters contained in the water may be precipitated, and discovered. It is not material which of these two methods be first practised, but it is quite necessary that the one should succeed the other. If we begin by evaporating and distilling, these operations must be sometimes interrupted, that the several principles which rise at different times of the distillation may be obtained and examined separately, and also to allow the several salts that may be contained, to crystallize by the evaporation and by

cold. *See* EVAPORATION, DISTILLATION, *and* CRYS-
LIZATION.

The ſubſtances generally found in mineral water
almoſt always combinations of vitriolic acid, and th
marine acid, together with the ſeveral matters that
acids are capable of diſſolving.

The following combinations of vitriolic acid are fo
mineral waters.

1. *Volatile ſulphureous acid.* This is ſeldom found
becauſe it eaſily loſes its phlogiſton, and becauſe it
almoſt always meet with ſome ſubſtance that it is capa
diſſolving.

2. *Sulphur.* This is found ſometimes ſingly, but
rally in form of a liver of ſulphur. In theſe waters, ſu
is formed into a hepar by means of calcareous earth or
neral alkali.

3. *Vitriolic ſalts with earthy baſes.* Theſe ſalts a
quently *ſelenitic*, that is, their acid is combined w
calcareous earth; or, they are of the nature of Epſom
the baſis of which is magneſia. Sometimes, but
frequently, they are *aluminous*, when their acid happ
be united with an argillaceous earth.

4. *Vitriols. Martial vitriol* is frequently contain
mineral waters; *vitriol of copper* is ſometimes, but ſe
and *vitriol of zinc* is ſtill more rarely found in theſe w
The vitriols of other metallic ſubſtances are ſcarcely
but in very ſingular caſes, found in water.

5. Laſtly, *vitriolic ſalts with baſis of fixed alkali.* T
always *Glauber's ſalt.* Neither *vitriolated tartar* nor *v
ammoniacal ſalt* are ever found, unleſs by ſome ſingul
cident, in mineral waters.

The combinations of marine acid that are contai
mineral waters are *common ſalt*, and *marine ſalt with
baſis.* For no combinations of this acid with phlogiſt
known, and it is very ſeldom found united with any m
ſubſtance.

Compounds formed of the nitrous acids are, in a ma
ſubſtances extraneous to the mineral kingdom, ſinc
acid is never produced but upon the ſurface of the
and from vegetable and animal matters. *See* ACID
TROUS) *and* NITRE. This acid cannot therefore be
in waters but very accidentally. Thus, for inſtance,
is found in the wells of Paris, and probably of other t
becauſe the ground where men inhabit is always nitro

These are the principal substances that form almost all these waters. We shall now shew the proofs by means of which they may be discovered in water, without decomposing the water by evaporation or by distillation.

If any portion of disengaged acid or alkali be contained in water, it may be known by the taste, by changing the color of violets or of turnsol, and by adding the precise quantity of acid or of alkali that is necessary for the saturation of the contained disengaged saline matter.

Sulphur, and liver of sulphur, may be discovered in waters by their singular smell, by the black color which these substances give to white metals or to their precipitates, but especially to silver.

Vitriolic salts with earthy basis may be discovered in water by two proofs: 1. By adding some fixed alkali, which decomposes all these salts, and precipitates their earthy basis; and, 2. By adding a solution of mercury in nitrous acid, which also decomposes these salts, and forms a *turbith mineral* with their acid. But for this purpose, the solution of mercury ought to have a superabundant quantity of acid: for this solution, when perfectly saturated, forms a precipitate with any kind of water, as M. Rouelle has very justly remarked; and indeed, all metallic solutions in any acids are strictly capable of decomposition by water alone, and so much more easily as the acid is more perfectly saturated with the metal.

Martial vitriol or iron combined with any acid, or even with gas, shews itself in waters by blackening an infusion of galls, or by forming a Prussian blue with the phlogisticated alkaline lixivium.

The vitriol of copper, or copper dissolved by any acid, may be discovered by adding some of the volatile spirit of sal ammoniac, which produces a fine blue color, or by the addition of clean iron, upon the surface of which the copper is precipitated in its natural or metallic state.

Glauber's salt is discovered by adding a solution of mercury in nitrous acid, and forming with it a turbith mineral; or by crystallization.

Common salt contained in waters forms with a solution of silver in nitrous acid a white precipitate, or luna cornea. It may also be known by its crystallization. Marine salt with earthy basis produces the same effect upon solution of silver. It also forms a precipitate when fixed alkali is added. The acrimony, bitterness, and deliquescency of this salt serve to distinguish it.

The proofs related for the examination of mineral wa
are only thoſe which are moſt eſſential. Many others
be made to confirm the former proofs: but the detail
theſe are too extenſive to be inſerted here. We ſhall
only two of theſe, becauſe they are very general, and
be very uſeful.

The firſt is the production of artificial ſulphur, or of
volatile ſulphureous acid; by which means the vitri
acid may be diſcovered in any combination whatever.
this purpoſe the matter to be examined muſt be mixed
any inflammable ſubſtance, and expoſed to a red-heat.
this matter contained but a particle of vitriolic aci
would be rendered ſenſible by the ſulphur, or by the v
tile ſulphureous acid thence produced. *See* SULPHUR.

The ſecond general proof for mineral waters which
ſhall mention here ſerves to diſcover any metallic ſubſt
whatever, diſſolved in water by any acid. This proof
ſiſts in adding ſome of the liquor ſaturated by the colo
matter of Pruſſian blue, diſcovered and deſcribed by
Macquer in his Memoir upon Pruſſian Blue. This li
produces no effects upon any neutral ſalts with earth
alkaline baſes, but decompoſes all metallic ſalts: fo
if no precipitate be formed upon adding ſome of this li
we may be certain that the water does not contain any
tallic ſalt; and on the contrary, if a precipitate is for
we may certainly infer that the water does contain
metallic ſalt.

We may eaſily perceive the neceſſity of uſing no v
in theſe experiments, but ſuch as are perfectly clean
rinſed with diſtilled water; of weighing the products o
experiments very exactly; of making the experiments
as large quantities of water as is poſſible, eſpecially
evaporations, cryſtallizations, and diſtillations; an
repeating all experiments ſeveral times. We may fu
obſerve, that the mixtures from which any precip
might be expected, ought to be kept two or three
becauſe many of theſe precipitates require that tim
more to appear, or to be entirely depoſited.

We ſhall now endeavour to explain how mineral w
become impregnated with their principles.

The *ſelenitic* parts of water are received by this
while it flows through gypſeous earth and ſtones,
being compoſed of ſelenites, which is ſoluble in water

The mines of ſal gem which are in many places
particularly where ſalt-ſprings are, furniſh the waters w

flow through them, and perhaps the sea itself, with the *common salt* that they contain.

When a water once contains common salt, it may become impregnated with *Glauber's salt* by passing through clay; the vitriolic acid that is always contained in argillaceous earths, decomposing a part of the common salt of the water, with the basis of which it forms the Glauber's salt; while the marine acid now disengaged will unite with the first calcareous particles that it meets, and form a *marine salt with earthy basis*, which is accordingly always found in sea-water, and in salt-springs.

When water impregnated, or not, with saline principles flows through parts of the earth containing pyrites in a state of decomposition, it becomes impregnated with *sulphur*, with *martial vitriol*, with *vitriol of copper*, with *alum*, and with *other salts*; and frequently with several of these substances at the same time, according to the nature of the pyrites. *See* PYRITES.

The *heat of hot mineral waters* can be only acquired by washing large masses of pyrites and other similar minerals in a state of spontaneous decomposition, during which they always acquire considerable heat.

Lastly, the aerial *gas* of some mineral waters may have been discharged from some of the principles with which the water is impregnated, which were in the act of combination with each other at the time they were dissolved by the water, or which were combined after this solution. For we know that in almost all solutions much air is extricated; and this air being well divided and diffused among the particles of water, adheres to them, and in some measure combines with them superabundantly. Mr. Venel has made upon this subject a fine experiment, that proves the truth of the above-mentioned theory, which was first given by him. He added to common water as much marine acid and mineral alkali as were sufficient to form as much common salt as is contained in the mineral water of Selters. He corked very well the bottle containing this impregnated water. The combination proceeded slowly and without effervescence, because the saline matters were much diluted; and when the combination was completed, the artificial water was become spirituous and aerial, like the natural water that he imitated. *See the particular articles of all the substances mentioned that relate to mineral waters; from a knowledge of the properties of which substances,*

 many

many explanations on this subject may be deduced, too long
here inserted. (*h*)

WATERS (MOTHER). This name is given to
liquor that remains after as much of the saline substa
contained in a water has been separated as can be by
the usual methods, evaporation and cooling, and f
which therefore no more crystals can be obtained, w
out much difficulty, though it still remains impregn
with salts. These mother-waters are very different,
cording to the kinds of salts with which the waters
originally impregnated. They are generally very he
acrid, and red.

The nature of mother-waters was a long time very
perfectly understood. They were considered as liq
lo

(*h*) The *gas* which gives the sparkling and inebriating
lities to many mineral waters, seems not to differ from the
extricated from effervescing and fermenting substances.
GAS. The Honourable Mr. Cavendish has added to his fo
important discoveries concerning different kinds of gas, one
throws much light on the nature of many mineral waters.
discovery is, that by means of gas, and without the interven
of any acid, calcareous earth is dissolved in some mineral
ters. He found that the quantity of this gas that was conta
in Rath-bone-place-water, relatively to the quantity of calca
earth contained in that water, was about twice as much
usually combined with an equal quantity of calcareous ea
and that the earth might be precipitated from this wat
driving off the gas by heat, or by absorbing it by the additio
lime-water. Does not this solution of calcareous earth b
confirm a conjecture concerning the analogy of this fluid
acids? It seems very extraordinary that calcareous earth satu
with its usual quantity of gas should be unsoluble in water,
that it may be rendered soluble, either by depriving it ent
of this gas, as it is in lime-water, or by uniting it with a su
abundant quantity of gas, as it is in the water of Rath-b
place, *See Phil. Trans. for the Year* 1767.

Mr. Lane has discovered another instance of the dissol
power of gas upon iron, and has, by some ingenious ex
ments, shewn the probability that this metal is dissolved in m
mineral waters by means only of that gas. He found that
distilled water, having been impregnated with the gas arising
effervescing or fermenting substances, was rendered capab
dissolving a sensible portion of iron; and that this artificial c
beate water, by exposure to air, lost entirely its propert
tinging an infusion of galls. As several chalybeate mi
w

loaded with greasy and viscid matters, by means of which the salts contained were prevented from crystallizing.

A portion of crystallizable salt, similar to those already extracted, does indeed remain in the mother-waters; and perhaps also the crystallization of these may be impeded by the viscid matters that are sometimes contained in these waters: but generally the greatest part of the matter contained in mother-waters is composed of salts that are deliquescent and different from those already obtained by crystallization. We are certain, at least, that the mother-waters of sea-salt and of nitre are formed almost entirely of these salts, which have a certain kind of adhesion to the crystallizable salts, and which therefore prevent the crystallization of the last portions of these. The mother-water of common salt contains a considerable quantity of marine salt with earthy basis, and the mother-water of nitre contains not only marine salt with earthy basis, but also a considerable quantity of nitre with earthy basis: hence, if a fixed alkali be added to these waters, a white earthy precipitate is formed so copiously, that the whole becomes a kind of paste. By diluting this paste with much water, the earth may be obtained by filtration. The earth when edulcorated is very white, and of a calcareous nature. It is called *magnesia*. (i)

If

waters do also, by exposure to air, entirely lose their property of tinging an infusion of galls; and as waters containing iron dissolved by means of vitriolic acid, though a considerable sediment is also deposited from them, do never entirely lose this property; he infers, that the former kind of waters receive their chalybeate impregnation by means, not of an acid, but of this gas. He further shews, from experiments, that iron cannot be so entirely precipitated from its solution in any of the mineral acids by means of mild alkalis, or mild calcareous earth, that this solution shall lose its power of tinging an infusion of galls; but that the iron may be so perfectly precipitated from the above-mentioned solutions by means of caustic alkali, or of lime-water; and hence he infers, that in the former case the portion of iron that is not precipitated is kept suspended or dissolved by means of the gas extricated by the acid of the solution from the mild alkali or earth. *See Phil. Trans. for the Year* 1769.

(i) Magnesia is an earth not convertible into quicklime, therefore different from calcareous earth, with which it is sometimes confounded, and is possessed of peculiar properties. *See the article* MAGNESIA, *and the* NOTE *subjoined.*

 The

If vitriolic acid be added to these mother-waters, a copious white precipitate is likewise formed. This p pitate also proceeds from the union of this acid wit calcareous earth of the earthy salts, by which a seleni formed. The selenites, not being soluble in so sm quantity of water as that of the mother-water employe mostly precipitated in form of an earthy sediment cons of very minute crystals. *See* SALTS *with* EARTHY B *and* MAGNESIA.

WATER *of* RABEL. The water of Rabel i triolic acid dulcified by mixture with rectified spirit of Rabel, the inventor of this liquor, which is used in dicine, employed an expensive apparatus in the prepar of it. He obtained the vitriolic acid from pyrites: since his time, the process has been much simplified, ought to be. One part of oil of vitriol is mixed three parts of rectified spirit of wine, and the mixtu digested in a well-closed vessel. The vitriolic acid upon all the principles of the spirit of wine, and com with them in a certain degree during this digestion: the acidity of the liquor is considerably diminished, bu perfectly destroyed. This water of Rabel may be cons as a dulcified vitriolic acid. *See* ETHER.

Water of Rabel is employed in medicine as an a gent, from the property which the vitriolic acid constringing the fibres and vessels. It requires to be ed in some proper vehicle, as in potions or juleps.

WATER (SEA). Sea-water, and the waters of salt-lakes, wells, and springs, containing various kin salts, is in much greater quantity than fresh-water.

We may say in general, that all natural salt-waters tain several kinds of salts, namely, common salt, ber's salts, selenites, Epsom salts, and marine salt earthy basis. These salts are in different quantitie proportions, according to the nature of the waters; b quantity of the common salt is always greater tha of any other.

All these waters have a saline, and more or less acrid, bitter taste. The acrimony and bitterness of waters are generally attributed to the bituminous m

The mother-waters of common salt and of nitre do also c some marine and nitrous salts with basis of calcareous ear appears from the formation of selenites upon adding vi acid, as is mentioned in the following paragraph of the te

sup

ſuppoſed to be contained in them: but I can affirm, that I have made many experiments on large quantities of theſe ſeveral waters, and that I could never find any ſenſible quantity of bitumen. The bitterneſs, therefore, of theſe waters ought to be attributed to the Glauber's ſalt, which is bitter, and eſpecially to the marine ſalt with earthy baſis, which is very bitter and acrid.

This notion of a bitumen being diſſolved in ſea-water has induced an opinion, that this water could not be rendered perfectly ſweet and fit for drinking merely by diſtillation, without ſome intermediate ſubſtance: and ſome authors, otherwiſe very intelligent, have recommended to mix with the ſea-water different ingredients, which they ſuppoſed fit to retain this bitumenous matter. Nevertheleſs, all the water that falls from the clouds, and all that flows on the ſurface of the earth and quenches the thirſt of animals, is nothing but ſea-water diſtilled and rendered ſweet, without any intermediate ſubſtance, by a natural evaporation. I am convinced from experience, that by means of a ſimple diſtillation, ſea-water may be rendered perfectly like the beſt river-water diſtilled. This truth appears from the following fact.

About twenty or twenty-five years ago, a ſtranger acquainted the Miniſter of the Marine department, that he was poſſeſſed of a ſecret to make ſea-water freſh, for the uſe of ſhips. The Miniſter ſent him to the Academy of Sciences in order to verify his proceſs. The Academy named Meſſrs. Bourdelin, Galiſſonier, and myſelf, to perform this office. The operation was made in my laboratory with ſea-water, brought purpoſely from Diepe, and which had been taken four leagues from land. The Author of the ſecret mixed with the part of this water which was to be purified from ſalt, a conſiderable quantity of white powder, which looked like flaked quicklime or powdered chalk, and the mixture was diſtilled in an alembic. We obtained a water perfectly ſweet, and which had all the properties of the beſt diſtilled water. As at that time I believed in the pretended bituminous matter of ſea-water, I wondered much at this proceſs, and I intended to make an advantageous report of it to the academy. Nevertheleſs, I thought it would be proper, firſt to diſtill the remainder of the ſea-water without any intermediate ſubſtance, which I accordingly did in the ſame alembic previouſly well waſhed. I conducted the diſtillation with a moderate fire, and with all the neceſſary attentions to procure

cure a pure and unmixed product, and I obtained a
fiderable quantity of water as good, and which ftoo
the tefts, as well as the water which had been dif
with the intermediate fubftance. I put fome of this
into bottles, fimilar to thofe which contained the
diftilled with the intermediate fubftance, and having
fented both of them to the author of the fecret, wi
telling him what I had done, he could not, upon ta
it and making the moft accurate trials of it, find
difference between the two waters. I then declared to
and to the members of the Academy, who were pre
the manner in which I had diftilled the water. The p
were repeated with the greateft care: And the author
took leave without faying a word, and I have not hea
him fince. I have fince that time had an opportuni
examining a falt-water, which we might expect to b
moft bituminous of all; I mean the water of the lak
phaltus, or the *dead-fea*. M. Guettard having fent to the
demy of Sciences feveral bottles of this water, which h
received from an intelligent traveller and good natur
Meffrs. Lavoifier, Sage, and I, were appointed to exa
it. The refult of our experiments on this water whic
found to be very falt, heavy, acrid, and bitter, was,
we obtained from it a good deal of common falt, of v
a part had cryftallized in the bottles, but efpecially, a
digious quantity of marine falt with earthy bafis, and
it gave no marks of its containing bitumen. *(k)*

Sea-

(k) It has been long known that a frefh water may be e
rated from the fea, and that the faline part was chiefly left be
On this principle, the common art of making falt, by fo
by artificial heat, is founded. The ancient navigators, ac
ing to Pliny, were ufed, when their frefh water was fcarc
avail themfelves of the natural evaporation of frefh water
the fea. *Quia fæpe navigantes defectu aquæ dulcis laborant*
quoque fubfidia demonftrabimus. Expanfa circa navim vellera
defcant, accepto halitu maris, quibus humor maris exprimitur.

But although the general principle was known, a prej
univerfally prevailed, that the water obtained by diftillati
fea-water, ftill remained impregnated with too much of a
or bituminous fubftance, to be ufed for the purpofe of fupp
the want of frefh water at fea. This prejudice probably
from the diftillation having been extended too far; for whe
greateft part of the fea-water is evaporated, the remaining li
being a highly concentrated brine, and of a greater denfity
w

Sea-water is not every where impregnated with an equal quantity of salt. Generally, it has been observed to contain more salt in hot than in cold climates. The quantity of common salt contained in sea-water is to the quantity of that water as three or four to a hundred. The water is consequently far from being saturated with that salt; for water is capable of dissolving nearly a fourth part of its weight of common salt.

Common salt is obtained from sea-water by evaporation alone, and not by alternate evaporation and cooling; because this salt is equally soluble in cold as in hot water. *See* CRYSTALLIZATION, *and* SALT (COMMON).

In the southern provinces of France, and in all equally hot or hotter climates, sea-water is evaporated in open air, and merely by the heat of the sun in summer, by which means the common salt is obtained. For this purpose,

water, is capable of receiving a so much greater degree of heat than was at first necessary to make the water boil, that not only the watery vapor, but also some of the saline parts, are raised in distillation. To prevent the exhalation of the saline part of the sea-water in distillation, various proposals were suggested of adding intermediate substances; as *lapis infernalis*, calcined bones, soap leys, powdered chalk, &c. and these methods were successively tried, and abandoned. The possibility, however, of obtaining a perfectly fresh water from sea-water merely by distillation without intervention of other substances, did not escape the Author of the Dictionary, as is above related, nor the zealous and successful researches of Dr. James Lind, Physician to the Royal Hospital at Haslar, to promote in every respect the health of seamen. This Gentleman publicly demonstrated in the year 1761, by several trials and experiments, that a simple distillation rendered sea-water perfectly fresh, pure and wholesome; and in May 1762, an account of this discovery was read to the Royal Society, and was soon afterwards published by authority of the Lords of the Admiralty. Nevertheless, the distillation of fresh water from sea-water was not brought into general use, whether from the inconvenience of keeping and employing an apparatus for distilling on board of ships, sufficiently large for the purpose required, or from the too great expence of fuel, or from the prejudices of mankind against new improvements; till Dr. *Charles Irving* invented a method of applying the *Ship's kettle*, or vessel commonly employed for cooking victuals, to the purpose of distilling fresh water, without any other additional apparatus than that of a copper tube bent nearly at right angles. The sea-water to be distilled was put into this kettle, which was therefore

poſe, large baſons are made in the ground near the
called ſalt-marſhes. They are ſo diſpoſed that the
water may flow into them at certain tides, and be re
ed there. Theſe marſhes are divided into many com
ments, communicating with each other, into which
required quantity of water may be admitted. The
in theſe is of a ſmall depth, that the evaporation ma
vance more quickly. When the water is ſufficiently
porated, and the ſalt is cryſtallized, more water is ad
ted, till a ſufficient quantity of ſalt is obtained, whi
then gathered in heaps and drained.

In the northern provinces of France common ſalt is
tained from ſea-water in the following manner:

A quantity of ſand moiſtened with ſea-water is exp
to the ſun and dried, which is quickly done, becauſ
ſea-water is almoſt entirely near the ſurface of the
The ſand, which then becomes covered with a conſide
quantity of ſalt, is to be waſhed with as much water

therefore employed as the body of a ſtill; and into the mou
the kettle was fitted the ſhorter leg of the tube, while the lo
leg ſerved to condenſe the ſteam during its paſſage throug
and to convey the condenſed water into any veſſel placed a
extremity of the tube to receive this water. In order to ac
rate the condenſation, he recommends to wet the tube freq
ly with a mop; by which means a continual evaporation
the external ſurface of the tube might be produced, much
might conſequently be carried off, and the vapor withi
tube might be cooled and condenſed. By this very ſimple a
ratus, he ſhews that a great quantity of freſh water may b
tained with an inconſiderable expence of fuel, with little
ble, and without any cumberſome veſſels. He particularl
ſtructs that only three-fourths of the ſea-water ſhould be diſt
as the water diſtilled from the remaining concentrated bri
found to have a diſagreeable taſte, and as the further con
ance of the diſtillation is apt to be injurious to the veſſels.
experience of thoſe ſhips in which this method has been
practiſed during long voyages, has evinced its utility, and
lity of execution. *See a journal of a voyage towards the*
Pole, by the Honourable Captain Phipps, to which is added a
pendix, giving a deſcription of Dr. Irving's apparatus, wit
account of its ſucceſs during that voyage.

Dr. *Prieſtly* has ſuggeſted a propoſal to give to this diſ
water *the briſkneſs and ſpirit of freſh ſpring water*, and a
ſame time of rendering it perhaps a *remedy* or *preventative* ag
the *ſcurvy*, by *impregnating it with the gas or fluid called fixe*
obtained by mixing chalk with oil of vitriol.

nece

necessary for the solution of the salt adhering to it; and this water is afterwards evaporated over the fire in leaden cauldrons, till the salt is crystallized.

Wallerius says, that in the northern countries the salt in sea-water is concentrated by exposure to intense cold, by which means great part of the water is frozen, and the unfrozen part, which contains almost all the salt, is afterwards evaporated by fire, till the salt is crystallized.

After the common salt has been thus obtained by these operations from sea-water, a liquor, called *mother-water*, remains, that contains much salt, which cannot be crystallized. If this water be further evaporated, and then exposed to cold, a certain quantity of Glauber's salt, and Epsom salt will be obtained.

Lastly, the remaining part of the mother-water contains scarcely any thing but marine salt with earthy basis, the earthy part of which may be precipitated by an alkaline lixivium. This earth is called the *Magnesia of common salt.* *See* WATER (MOTHER), *and* MAGNESIA.

WATER *of* SALT-SPRINGS. The water of almost all salt-springs, at least of those from which common salt is obtained, contains exactly the same principles as sea-water, but generally in a larger quantity. Some of these springs contain sixteen pounds of salt in a hundred pounds of water. Such, for instance, is that of Dieuse in Lorraine, one of the best salt-works known. Other springs contain a much smaller proportion of salt; such is that of Montmorat in Franche-compté.

Salt is obtained from these salt-springs generally by evaporation over the fire; at least, it is so in Lorraine, and in Franche-compté: but that the expence of fuel may be lessened, the water, when weakly impregnated, is previously concentrated by frequently pouring it upon bundles of twigs or faggots under buildings that are covered, but open at all the sides, called *graduating houses*. The water raised by pumps to the top of these buildings falls upon the faggots, by which it is divided into a shower, its surface is thereby encreased, and the evaporation is promoted by the free current of air that passes through the open sides of the building. When, by this means, the water is so concentrated that a hundred pounds of it contain about thirteen or fourteen pounds of salt, it is then evaporated over the fire in the usual manner.

As these waters are much more impregnated with saline principles than sea-water, and as their evaporation is more quickly

quickly finiſhed, we ſhall confirm what we have ſaid c
cerning the evaporation and formation of the ſeveral
in ſea-water, by deſcribing the method employed in
evaporation of the water of the ſalt-ſprings of Lorraine
Franche-compté.

This water is evaporated in very large veſſels mad
plates of iron, capable of containing from eight to nin
ten thouſand gallons of water, called *ſalt-pans*, the d
of which is about fifteen or ſixteen inches.

In theſe the water is boiled ſome time, during whi
ſaline earthy matter, called *ſchlot* or *ſcratch*, is depoſ
and is carefully to be ſeparated. This ſcratch is a ſelen
which of all the ſaline matters contained in the wat
the leaſt ſoluble, and conſequently cryſtallizes firſt. T
ſelenites draws along with it ſome of the other ſalts,
principally Glauber's ſalt, which ſeems to have ſome
gree of adheſion to it.

When the ſelenites is ſeparated, the common ſalt, b
in greater quantity than the other ſalts, begins to cry
lize and form cubes. That larger cryſtals of this ſalt
be formed, the water is made to boil very ſlowly, till
common ſalt ceaſes to cryſtallize. The water that rem
is very heavy, much impregnated with ſalt, of an a
and bitter taſte. This is the *mother-water*.

This mother-water contains ſtill ſome common
ſome Glauber's ſalt, and eſpecially a large quantity of
rine ſalt with earthy baſis. The Glauber's ſalt rem
chiefly in the mother-waters, becauſe it is much more ſ
ble in hot than in cold water, and cryſtallizes more rea
by cold than by evaporation. The marine ſalt with ea
baſis remains almoſt entirely in the mother-water, bec
it is deliqueſcent, and not ſuſceptible of a true cryſt
zation. *See* WATER (MOTHER).

The ſeveral ſalts contained in waters of ſalt-ſpring
thus ſeparated from each other: but this ſeparation is
very accurate. To render it more complete, other m
muſt be employed. The fundamental principles of
perfect purification of the ſeveral ſalts confounded t
ther in the ſame water are explained at the article CRYST
LIZATION. To avoid repetitions, we refer to that art
See alſo the articles SELENITES, SALT (COMMON), S
of EPSOM, SALT *of* GLAUBER, SALT (MARINE)
EARTHY BASIS, WATER (MOTHER), *and* WAT
(MINERAL).

WAX. Wax is an oily, concrete matter gathered by bees from plants.

Wax has been long confidered as a refin, from fome properties common to it with refins. It has the fame confiftence as refins have, and, like them, it furnifhes an oil and an acid by diftillation, and is foluble in all oils: but in feveral refpects it differs fenfibly from refins. Like thefe, wax has not a ftrong aromatic tafte and fmell, but a very weak fmell, and, when pure, no tafte. With the heat of boiling water no principles are diftilled from it; whereas, with that heat, fome effential oil, or, at leaft, a fpiritus rector is obtained from every refin. Further, wax is unfoluble in fpirit of wine. If wax be diftilled with a heat greater than that of boiling water, it may be decompofed, but not fo eafily as refins can. By this diftillation a fmall quantity of water is firft feparated from the wax, and then fome very volatile and very penetrating acid, accompanied with a fmall quantity of a very fluid and very odoriferous oil. As the diftillation advances, the acid becomes more and more ftrong, and the oil more and more thick, till its confiftence be fuch that it becomes folid in the receiver, and is then called *butter of wax*. When the diftillation is finifhed, nothing remains but a fmall quantity of coal, which is almoft incombuftible from the want of fome faline matter. *See* COAL.

Wax cannot be kindled, unlefs it be previoufly heated and reduced into vapors; in which refpect it refembles fat oils. The oil and butter of wax may, by repeated diftillations, be attenuated and rendered more and more fluid, becaufe fome portion of acid is thereby feparated from thefe fubftances; which effect is fimilar to what happens in the diftillation of other oils and oily concretes: but this remarkable effect attends the repeated diftillation of oil and butter of wax, that they become more and more foluble in fpirit of wine; and that they never acquire greater confiftence by evaporation of their more fluid parts. Boerhaave kept butter of wax in a glafs veffel open, or carelefsly clofed, during twenty years, without acquiring a more folid confiftence. We may remark, that wax, its butter, and its oil, differ entirely from effential oils and refins in all the above-mentioned properties, and that in all thefe they perfectly refemble fweet oils. *See* OILS (ESSENTIAL), RESINS, *and* OILS (SWEET EXPRESSED).

We may therefore conclude from what has been faid, as Mr Macquer has done in his Elements of Chemiftry, and

and in his Memoir upon Oils, that wax only resem
resins in being an oil rendered concrete by an acid
that it differs essentially from these in the kind of th
which in resins is of the nature of essential oils, wh
wax and in other analogous oily concretions, (as but
milk, butter of cocoa, fat of animals, sperma-ceti,
wax obtained from a tree in Louisiana) it is of the n
of sweet, unctuous oils that are not aromatic, and
volatile, and are not obtained from vegetables by expre

Wax is very useful, especially as a better material
any other for candles.

Wax may be deprived of its natural yellow disagre
color, and be perfectly whitened, by exposure to the u
action of air and water, by which method the col
many substances may be destroyed.

The art of bleaching wax consists in encreasing its su
For which purpose, it must be melted with a degree of hea
sufficient to alter its quality, in a cauldron so disposed
the melted wax may flow gradually through a pipe at the
tom of the cauldron into a large tub filled with water, in v
is fitted a large wooden cylinder, that turns continually r
its axis, and upon which the melted wax falls. As the
face of this cylinder is always moistened with cold w
the wax falling upon it does not adhere to it, but qu
becomes solid and flat, and acquires the form of ribb
The continual rotation of the cylinder carries off
ribbands as fast as they are formed, and distributes
through the tub. When all the wax that is to be wh
ed is thus formed, it is put upon large frames covered
linen cloth, which are supported about a foot and a
above the ground, in a situation exposed to the air,
dew, and the sun. The thickness of the several ribb
thus placed upon the frames, ought not to exceed
inch and a half; and they ought to be moved
time to time, that they may all be equally exposed t
action of the air. If the weather be favorable, the
will be changed in the space of some days. It is th
be re-melted and formed into ribbands, and expos
the action of the air as before. These operations a
be repeated till the wax be rendered perfectly white,
then it is to be melted into cakes, or formed into car

The yellow color of the wax is evidently destroyed b
combined action of the air, of the water, and of the sun.
the volatile, sulphureous acid has the property of des
ing still more quickly almost all the colors of veget

pe

perhaps this bleaching might be shortened by exposing ribbands of yellow wax to the vapor of sulphur, as is practised for wool and silk. (l)

Every kind of wax is not equally capable of being whitened, the color of some adhering so strongly, that it cannot be effaced. Such is the wax that comes from countries in which vines grow. This observation I have received from Mr. Trudon, proprietor of the manufactory of wax at Antoni, near Paris.

Wax is employed for many purposes in several arts. It is also used in medicine as a softening, emollient, and relaxing remedy: but it is only used externally, mixed with other substances. It is an ingredient in many pomatums,

(l) The above operation of bleaching wax can be performed well in fine weather only, as it depends chiefly on the action of the sun. This circumstance being attended with much inconvenience to the manufacturers, the discovery of a method of whitening wax, independantly of the seasons, would be very useful, and has been recommended to the attention of chemists by some economical Societies. With a view to discover such a method, Mr. *Beckman* has made experiments, an account of which is published in the 5th volume of the *Novi commentarii Societatis regiæ Scientiarum Gottingensis*. According to these experiments, thin pieces of yellow wax were whitened and hardened by being digested and boiled in diluted and undiluted nitrous acid in a few hours. But the wax thus whitened being melted by means of boiling water, was observed to acquire a yellow color, less intense, however, than it was before it had been treated with the mineral acids. The marine and vitriolic acids were less effectual than the nitrous. He exposed wax to the flames of burning sulphur, but without success. Yellow wax being melted in vinegar was rendered of a grey color. The oil of tartar whitened wax, but less effectually than acids had done; and this wax being washed in water and afterwards digested in nitrous acid was rendered still more white; but upon melting it in water, a yellowish tinge returned. He liquefied wax in solutions of nitre and alum, but without any good effect. Spirit of wine, which is recommended by Boyle for this purpose, did indeed whiten the wax, but changed the wax to a butyraceous substance, so frothy that its bulk was encreased thirty times. Reflecting that tartar is purified from its oily particles by means of a calcareous earth, he tried the effects of a kind of Fuller's earth, which he threw upon wax liquefied in water, and he agitated the mixture. This method rendered wax of a greyish color, and is therefore recommended by him as preparatory to bleaching, the time necessary for which, he thinks, may be thus greatly shortened.

 cerates,

cerates, ointments, and plasters, to most of which it
the due consistence. Upon this subject may be con
Mr. Beaumé's Elements of Pharmacy, a work conta
many excellent observations.

WEIGHTS. *(m)*

WHEY. *See* MILK.

WHITE (SPANISH). This name is given t
different substances, namely, the *magistery of bismuth*
the washed *chalk* used for painting in water-colors.

WHITE-LEAD. This name is given to the
rust produced by exposing lead to the vapors of vinega
is also called *cerus*. *See* CERUSS.

WINE. Chemists give the name of *wine* in gene
all liquors that have become spirituous by ferment
Thus *cyder*, *beer*, *vinous hydromel*, or *mead*, and othe
lar liquors, are wines.

The principles and theory of the fermentation whic
duces these liquors are essentially the same. The mo

(m) WEIGHTS. As the weights mentioned in this Dic
are French, it is proper to explain them, and compare the
the English.

The *Paris pound* contains 2 marks, and is to the Engli
pound as 21 to 16. It is equal to 7560 troy grains.

The *Paris marks* contains 8 Paris ounces.

The *Paris ounce* contains 8 Paris drams, or gros; and i
to 472 $\frac{1}{2}$ troy grains.

The *Paris dram*, or *gros*, contains 3 Paris scruples, or d
and is equal to 72 Paris grains, or to 59 $\frac{1}{2}$ troy grains.

The *Paris scruple* or *denier* contains 24 Paris grains, and i
to 19 $\frac{11}{48}$ troy grains.

The *Paris grain* is the $\frac{1}{9216}$th part of a Paris pound, a
the troy grain as 7560 to 9216.

The *English troy pound* contains 12 ounces,

The *Troy ounce* contains 20 pennyweights.

The *Troy pennyweight* contains 24 grains.

The *English medicinal* or *Apothecary's pound* is the same
troy pound, but is otherwise divided.

The *Apothecary's pound* contains 12 ounces.

The *Apothecary's ounce* contains 8 drams.

The *dram* contains 3 scruples.

The *scruple* contains 20 grains.

The *grain* is the same as the troy grain.

The *Averdupoise pound* contains 16 averdupoise ounces,
equal to 7004 troy grains, or is to the troy pound as 10
nearly.

neral principles we have explained under the article FERMENTATION. At the articles BEER and HYDROMEL may be found some peculiarities relative to these kinds of wines. In the present article we shall chiefly attend to the *wine of grapes*, to which the name of *wine* is more particularly applied. At the same time, we shall not neglect any thing relating to spirituous fermentation in general.

All vegetable and animal matters, which have a taste sweet, agreeable, and more or less saccharine, and which are nutritive, are susceptible of the spirituous fermentation. Thus wine may be made of all the juices of plants, the sap of trees, the infusions and decoctions of farinaceous vegetables, the milk of frugivorous animals, which is possessed of the above-mentioned qualities; and, lastly, it may be made of all ripe succulent fruits, which also are possessed of these qualities; but all these substances are not equally proper to be changed into a good and generous wine.

As the production of ardent spirit is the result of the spirituous fermentation, we may consider that wine as essentially the best which contains most of this spirit. But of all substances susceptible of the spirituous fermentation, none is capable of being converted into so good wine, as the juice of the grapes of France, or of other countries that are nearly in the same latitude, or in the same temperature. The grapes of hotter countries, and even those of the southern provinces of France, do indeed furnish wines that have a more agreeable, that is, more of a saccharine taste; but these wines, though they are sufficiently strong, are not so spirituous as those of the provinces near the middle of France: at least, from these latter wines the best vinegar and aqua vitæ are made. As an example, therefore, of spirituous fermentation in general, we shall describe the method of making wine from the juice of the grapes of France.

This juice, when newly expressed, and before it has begun to ferment, is called *must*, and in common language *sweet wine*. It is turbid, has an agreeable and very saccharine taste. It is very laxative, and when drank too freely, or by persons disposed to diarrhæas, it is apt to occasion these disorders. Its consistence is somewhat less fluid than that of water, and it becomes almost of a pitchy thickness when dried.

When the must is pressed from the grapes, and put into a proper vessel and place, with a temperature from ten or twelve degrees to fifteen or sixteen, very sensible effects

are produced in it, in a ſhorter or longer time, ac
to the nature of the liquor, and the temperature of th
It then ſwells, and is ſo rarefied, that it frequent
flows the veſſel containing it, if this be nearly fu
inteſtine motion is excited among its parts, accor
with a ſmall hiſſing noiſe and evident ebullition
bubbles riſe to the ſurface, and, at the ſame time
engaged a vapor which is probably of a phlogiſtic
and is ſo ſubtle and dangerous, that it is capable of
inſtantly men and animals expoſed to it in a place w
air is not renewed. In its effects this vapor is ſir
that of burning charcoal. The ſkins, ſtones, an
groſſer matters of the grapes, are buoyed up by the
of diſengaged air that adhere to their ſurface, are
agitated, and are raiſed in form of a ſcum or ſoft and
cruſt that covers the whole liquor. During the fe
tion this cruſt is frequently raiſed, and broken b
diſengaged from the liquor, which forces its way
it: afterwards the cruſt ſubſides, and becomes e
before.

These effects continue while the fermentation
and at laſt gradually ceaſe: then the cruſt being no
ſupported, falls in pieces to the bottom of the liqu
this time, if we would have a ſtrong and generous
ſenſible fermentation muſt be ſtopt. This is done by
the wine into cloſe veſſels, and carrying theſe into
or other cool place.

After this firſt operation, nature tends ſpontaneo
kind of reſt, as is indicated by the ceſſation of the
effects of the ſpirituous fermentation; and thus
us to preſerve a liquor no leſs agreeable in its ta
uſeful for its reviving and nutritive qualities whe
moderately.

If we examine the wine produced by this firſt f
tion, we ſhall find that it differs entirely and eſſenti
the juice of grapes before fermentation. Its ſweet
charine taſte is changed into one that is very
though ſtill agreeable, and ſomewhat ſpirituous and
It has not the laxative quality of muſt, but affects
and occaſions, as is well known, drunkenneſs.
if it be diſtilled, it yields, inſtead of the inſipid w
tained from muſt by diſtillation with the heat o
water, a volatile, ſpirituous, and inflammable liqu
ſpirit of wine, or *ardent ſpirit*. This ſpirit is con

being, produced by the kind of *fermentation* called
ous or *ſpirituous*. *See* SPIRIT (ARDENT).

on one ſide, the liquors ſuſceptible of the ſpirituous
tation contain chiefly a ſweet oil rendered miſcible
ater by means of an acid; and as, on the other ſide,
ıor produced by the ſpirituous fermentation is inflam-
but ſtill miſcible with water, and conſequently
ſed of a watery and inflammable principle; we may
erceive, that the work of nature chiefly conſiſts in
ting, dividing, and volatiliſing the oily parts of fer-
le matters, and in combining theſe intimately with
tery principle. But by what mechaniſm does nature
this change? In what does attenuation of the oily
recifely conſiſt? In what proportion is this oil, or
s inflammable principle, united with the watery prin-
the compoſition of ardent ſpirit? Theſe are myſteries
re that are ſtill entirely hid from us, and which we
eaſily explain. Without entering, therefore, into
ılation concerning the production of ardent ſpirit,
ll proceed in the hiſtory of ſpirituous fermenta-

en any liquor undergoes the ſpirituous fermentation,
parts ſeem not to ferment at the ſame time, otherwiſe
nentation would probably be very quickly compleated,
e appearances would be much more ſtriking: hence,
quor much diſpoſed to fermentation, this motion is
quick and ſimultaneous than in another liquor leſs
d. Experience has ſhewn, that a wine, the fermen-
of which is very ſlow and tedious, is never good
ery ſpirituous; and therefore, when the weather
cold, the fermentation is uſually accelerated by
the place in which the wine is made. A pro-
which I think is a good one, has been made by a
very intelligent in economical affairs, to employ a
than the uſual heat to accelerate the fermentation of
in thoſe years in which grapes have not been ſuffi-
ripened, and when the juice is not ſufficiently diſ-
o fermentation.

o haſty and violent fermentation is perhaps alſo hurt-
om the diſſipation and loſs of ſome of the ſpirit: but
we are not certain. However, we may diſtinguiſh,
ordinary method of making wines of grapes, two
in the fermentation, the firſt of which laſts during
pearance of the ſenſible effects above-mentioned, in
the greateſt number of fermentable particles do fer-
ment.

ment. After this first effort of fermentation, thes
sensibly diminish, and ought to be stopped, for reason
after to be mentioned. The fermentative motion
liquors then ceases. The heterogeneous parts th
suspended in the wine by this motion, and which
it muddy, are separated, and form a sediment ca
lees; after which the wine becomes clear: but a
the operation be then considered as finished, and
mentation apparently ceases, it does not really cease
ought to be continued in some degree, if we wou
good wine. In this new wine a part of the liquor
that has not fermented, and which does afterwards
but so very slowly, that none of the sensible effe
duced in the first fermentation are here perceived
fermentation, therefore, continues still in the wine,
a longer or shorter time, although in an imper
manner; and this is the second period of the spiritu
mentation, which may be called the *imperceptible f
tion*. We may easily perceive, that the effect of
perceptible fermentation is the gradual encrease
quantity of spirit in wine. It has also another
less advantageous, namely, the separation of a salin
earthy matter, called *tartar*, from the wine. This
is therefore a second sediment that is formed in th
and which adheres to the sides of the containing
As the taste of tartar is harsh and disagreeable, it is
that the wine, which, by means of the insensible
tation, has acquired more spirit, and has disengag
of the greatest part of its tartar, ought to be muc
and more agreeable; and for this reason chiefly, old
universally preferable to new wine.

But insensible fermentation can only ripen and
the wine, if the sensible fermentation has regula
ceeded, and has been stopped in due time. W
certainly, that if a sufficient time has not been allo
the first period of the fermentation, the unfermente
that remains, being in too large a quantity, will then
in the bottles, or close vessels in which the wine is
will occasion effects so much more sensible, as
fermentation shall have been sooner interrupted
these wines are always turbid, emit bubbles, and so
break the bottles, from the large quantity of air an
that are disengaged during the fermentation. We
instance of these effects in the white wine of Cha
and in others of the same kind. The sensible ferm

ese wines is interrupted, or rather ſuppreſſed, that they have this ſparkling quality. It is well known that wines make the corks fly out of the bottles, that they kle and froth when they are poured into glaſſes, and, , that they have a taſte much more lively and more ant than wines that do not ſparkle; but this ſparkling ty, and all the effects depending on it, are only cauſed conſiderable quantity of air which is diſengaged during onfined fermentation which the wine has undergone in veſſels. This air, not having an opportunity of ing, and of being diſſipated as faſt as it is diſengaged, being interpoſed betwixt all the parts of the wine, bines in ſome meaſure with theſe, and adheres in the manner as it does to thoſe mineral waters that are called tuous, in which it produces nearly the ſame effects. en this air is entirely diſengaged from theſe wines, they onger ſparkle, they loſe their piquancy of taſte, become , and even almoſt inſipid.

ch are the qualities that wine acquires in time, when irſt fermentation has not continued ſufficiently long. ſe qualities are given purpoſely to certain kinds of wine, ndulge taſte or caprice; but ſuch wines ought not to aily drank. Wines for daily uſe ought to have under- ſo compleatly the ſenſible fermentation, that the ſuc- ing fermentation ſhould be inſenſible, or, at leaſt, ex- ingly little ſenſible. Wine, in which the firſt fermen- n has been too far advanced, is liable to worſe incon- ences than that in which the firſt fermentation has been quickly ſuppreſſed; for every fermentable liquor is from ature in a continual fermentative motion, more or leſs ng, according to circumſtances, from the firſt inſtant of ſpirituous fermentation, till it is compleatly putrefied: ce from the time of the completion of the ſpirituous entation, or even before, the wine begins to undergo acid or acetous fermentation. This acid fermentation is ſlow and inſenſible when the wine is included in very veſſels, and in a cool place; but it does gradually nce, ſo that in a certain time the wine, inſtead of being iorated, becomes at laſt ſour. This evil cannot be edied, becauſe the fermentation may advance, but not be reverted. Wine-merchants, therefore, when r wines become ſour, can only conceal or abſorb this ity by certain ſubſtances, as by alkalis and abſorbent hs. But theſe ſubſtances give to wine a dark-greeniſh r, and a taſte, which, though not acid, is ſomewhat

 diſagreeable.

is ſomew
diſagreeable

diſagreeable. Beſides, calcareous earths accelerate
ſiderably the total deſtruction and putrefaction of the
Calxes of lead, having the property of forming with th
of vinegar a ſalt of an agreeable ſaccharine taſte, which
not alter the color of the wine, and which beſides ha
advantage of ſtopping fermentation and putrefaction,
be very well employed to remedy the acidity of wi
lead and all its preparations were not pernicious to h
as they occaſion moſt terrible colics, and even death,
taken internally. We cannot believe that any wine-
chant, knowing the evil conſequences of lead, ſhoul
the ſake of gain, employ it for the purpoſe mentioned
if there be any ſuch perſons, they muſt be conſidered
poiſoners and murderers of the public.

If wine contains litharge, or any other calx of le
may be diſcovered by evaporating ſome pints of it to dr
and melting the reſiduum in a crucible, at the botto
which a ſmall regulus of lead may be found after the fu
but an eaſier and more expeditious proof is by pourin
the wine ſome liquid liver of ſulphur. If the preci
occaſioned by this addition of the liver be white, o
colored by the wine, we may know that no lead is
tained: but if the precipitate be dark-colored, brow
blackiſh, we may be certain that lead is contained.

The only ſubſtances that cannot abſorb or deſtroy
cover and render ſupportable the ſharpneſs of wine, wi
any inconvenience, are ſugar, honey, and other ſacc
alimentary matters; but they can ſucceed only whe
wine is but very little acid; and when an exceeding
quantity only of theſe ſubſtances is ſufficient to produ
deſired effect; otherwiſe the wine would have a ſwe
tart, and not agreeable taſte.

From what we have ſaid concerning the aceſcency of
we may conclude, that when this accident happens, it c
by any good method be remedied, and that nothing re
to be done with ſour wine but to ſell it to vinegar-m
as all honeſt wine-merchants do. We may obſerve
the firſt ſenſible fermentation having been too far adva
is not the only cauſe of the acidity of wine, but
heat alſo is capable of producing the ſame effect.
wine, which might have been long preſerved in a
place, very quickly becomes ſour, when placed in
cellar; and even as the beſt cellars have during the
a degree of heat much ſuperior to that of the atmoſ
it would be very proper, when wine diſpoſed to b

is to be preſerved, to bring it from the cellar in the nning of winter, and leave it expoſed to the air during nat ſeaſon.

Vine is alſo liable to other changes; as, to become and mucilaginous, by the continuance of the fermen- e motion: but we cannot proſecute theſe details in a of this kind. Beſides, the ſpirituous fermentation, its conſequences, ſtill require a further examination, h we hope will be performed in a ſatisfactory manner, ſeveral Academies, ſenſible of the importance of the ect, have offered prizes for diſcoveries relative to it. that we can at preſent ſay is, that the fundamental ciples from which we may deduce a more accurate vledge on this ſubject, may be diſcovered by deter- ng with what degree of heat, and during what time, irſt ſenſible fermentation of muſt ought to be promoted, the moſt ſpirituous and beſt keeping wine may be ined. I confeſs that this object is very extenſive, and difficult to be known in a general manner, conſider- how variable theſe things are, and what differences, aps greater than we now imagine, there ought to be, rding to the nature of the muſt, which varies exceed- y in different countries, and at different times. Expe- ce and obſervation have already inſtructed makers of e in many things relative to this ſubject; but much yet ains to be determined, which is not within the reach of nary country people, or even of the proprietors of the t vine-yards.

Vine, and the matters produced from wine, as brandy, it of wine, vinegar, lees of wine, tartar, are greatly extenſively uſeful. The lees of wine are employed in manufacture of hats. Theſe lees, and alſo tartar by ineration, yield a larger quantity than any other vege- le matter of pure fixed alkali. *See the articles* AQUA TÆ, SPIRIT *of* WINE, TARTAR, *and* VINEGAR.

Vine has been preferred in all times and in all countries every other alimentary liquor. We may ſay in general, t it is good and ſalutary when taken in ſmall quantities, l that it is pernicious when drank habitually, and in large quantities. Wine becomes then a true ſlow ſon, which is ſo much more dangerous, as it is more eeable. But if we obſerve more particularly the effects wine, we ſhall perceive very great differences depending different conſtitutions. Some perſons drink habitually ge quantities of pure wine, without any ſenſible incon- venience

venience or diseafe, or fhortening their lives: but,
contrary, many others do alfo entirely deftroy their
and fhorten their lives, by an habitual ufe of wine
fmall quantity, and mixed with water. Althoug
always more fafe and prudent for every perfon to
little of it habitually, this moderation is more indifp
neceffary to thofe whofe conftitutions wine does not

As the difeafes confequent upon the too free ufe
come gradually and infenfibly, fometimes even durin
years, feveral perfons, efpecially men, otherwife ver
and attentive to health, are every day deceived up
article, drinking more wine than is fuitable to the
ftitution, and gradually ruining their health without
ing the caufe. It is therefore a matter of import
fhew the figns by which wine may be known to be
We may know that wine does not fuit a perfon, whe
drinking moderately of it, his breath acquires a
fmell; when it occafions four belchings and fligh
in the head; and when, after drinking it more co
than ufual, it produces ftupefaction, naufea, and dr
nefs, efpecially when this drunkennefs is of the
peevifh, quarrelfome, and irafcible kind. Unhappy
perfon who fuffers thefe effects from wine, and n
ftanding contracts and perfifts in the habitual uf
Thefe imprudent perfons do never fail of comin
miferable death, preceded by languor, and pren
their common age being about fifty years, or a littl
The difeafes to which they are moft fubject are obftr
in the liver, in the mefenteric glands, and in other ab
vifcera, which are almoft always fucceeded by an in
dropfy. Thofe who digeft wine well, do not fu
much lefs fenfibly, the above-mentioned effects of d
it. Their drunkennefs is accompanied with vivac
joy. Such perfons feldom die of the obftructio
dropfy above-mentioned: but wine is neverthelefs
more dangerous to them, that as they fuffer none of
agreeable effects, they are more liable to contract t
of drinking too much. Drinkers of this clafs g
live fomewhat longer than the former; but their c
tion generally changes before fixty years of age;
inheritance of their old age is either a fevere gout o
ftupidity, imbecillity, or an accumulation of thefe

We need not mention that the too frequent ufe of
ratafia, and of other fpirituous liquors is ftill muc
pernicious and fatal than of wine.

Vine is uſed in medicine as a vehicle in the compoſition
many internal and external remedies. As wine is com-
d of an ardent ſpirit, water, extractive ſaponaceous
er, and acid of tartar, it may be very uſefully employed
the extraction of almoſt all the proximate principles,
conſequently of the medicinal parts, of vegetables,
ny extracts are made with wine, which may be conſidered
eing more compleat than thoſe made with water: but
icians who preſcribe theſe extracts ought to remember,
, beſides the principles of the vegetables, they alſo
ain the extractive part of the wine, that is, all the
ciples of wine, excepting the ardent ſpirit, which is too
tile to remain in an extract.

s wine, when good, may be preſerved during a long
, ſeveral medicinal wines preſcribed in Diſpenſatories
kept in the ſhops of apothecaries. Such are the aſtrin-
t, antiſcorbutic, febrifugal wines of the Peruvian bark,
wormwood, chalybeate wine, and others. In many
s, as in ſeveral chronical diſeaſes, where tonic, cordial,
ifying and exciting remedies are indicated, phyſicians
er the uſe of wine to water, as a vehicle for the in-
on of purgative, aperitive, and other medicinal ſub-
ces.

VOAD. *(n)*

WOLF-

n) WOAD. Dr. Lewis, in a note to his edition of Neuman's
emical Works, gives the following account of woad.

Voad, iſatis, glaſtum, is a plant with long green leaves; the
er ones narrow at both ends; thoſe which grow upon the ſtalk
broad at bottom like an arrow-head. On the tops come
th numerous yellow flowers, which are followed by little flat
ls containing the ſeeds. It grows wild in ſome parts of France,
on the coaſts of the Baltic Sea: the wild woad, and that
ich is cultivated for the uſe of dyers, appear to be the ſame
cies of plant. The preparation of woad for dying, as prac-
d in France, is minutely deſcribed by Aſtruc, in his Memoirs
a Natural Hiſtory of Languedoc. The plant puts forth at
t five or ſix upright leaves, about a foot long and ſix inches
ad: when theſe hang downwards, and turn yellow, they are
for gathering: five crops are gathered in one year. The leaves
carried directly to a mill, much reſembling the oil or tan-
lls, and ground into a ſmooth paſte. If this proceſs was de-
red for ſome time, they would putrefy, and ſend forth an in-
pportable ſtench. The paſte is laid in heaps, preſſed cloſe and
ooth, and the blackiſh cruſt, which forms on the outſide, re-
ited if it happens to crack: if this was neglected, little worms
would

WOLFRAM. (o)

would be produced in the cracks, and the woad would lose a p of its strength. After lying for fifteen days, the heaps are open the crust rubbed and mixed with the inside, the matter form into oval balls, which are pressed close and solid in wood moulds. These are dried upon hurdles: in the sun, they tu black on the outside; in a close place, yellowish, especially the weather be rainy: the dealers in this commodity prefer t first, though it is said the workmen find no considerable differen betwixt the two. The good balls are distinguished by th being weighty, of an agreeable smell, and when rubbed, of violet color within. For the use of the dyer, these balls requ a further preparation: they are beat with wooden mallets, on brick or stone floor, into a gross powder; which is heaped up the middle of the room to the height of four feet, a space bei left for passing round the sides. The powder, moistened w water, ferments, grows hot, and throws out a thick fetid fum It is shovelled backwards and forwards, and moistened every d for twelve days; after which it is stirred less frequently, witho watering, and at length made into a heap for the dyer.

The powder thus prepared gives only brownish tinctures, different shades, to water, to rectified spirit of wine, to volat alkaline spirits, and to fixed alkaline lixivia: rubbed on pap it communicates a green stain. On diluting the powder w boiling water, and after standing some hours in a close vess adding about one twentieth part of its weight of lime new slaked, digesting in a gentle warmth, and stirring the whole t gether every three or four hours, a new fermentation begins, blue froth arises to the surface, and the liquor, though it appea itself of a reddish color, dyes woollen of a green, which, like t green from Indigo, changes in the air to a blue. This is one the nicest processes in the art of dying, and does not well su ceed in the way of a small experiment.

Astruc proposes the manufacturing of fresh woad leaves in E rope, after the same manner as the Indigo plant is manufactur in America; and thus preparing from it a blue fecula similar indigo, which from his own experiments he has found to be pra ticable. Such a management would doubtless be accompani with some advantages, though possibly, woad so prepare might lose those qualities which now render it, in a lar business, preferable on some accounts to indigo, as occasionin greater dispatch when once the vat is ready, and giving out i color less hastily, so as to be better fitted for dying very lig shades.

(o) Wolfram, *Spuma lupi*, is a very refractory mineral of black or dusky color, crystallized in form of cubes, striæ, or oth determinate shape, and consisting of shining plates. Its appea

an

OOL (PHILOSOPHIC). This is a name by ancient chemical or alchemical authors to flowers nc. See FLOWERS of ZINC.

ORMWOOD. (p)

ELLOW. (q)

is similar to the ore of tin, called tin-grains or cryftals of tin: t is frequently found in tin-mines. It is fo hard that it can fparks from fteel. When powdered, it is red. Wallerius ders it as an ore of iron mineralifed by arfenic, which fome- contains tin. According to Cronftedt, it is a kind of mag- or manganefe, containing a fmall portion of iron and of

) WORMWOOD. The leaves of wormwood are intenfely r, and have a ftrong fmell, fomewhat of the aromatic kind. yield in diftillation a confiderable quantity of effential oil dark greenifh color poffeffing the whole of their fmell, the r matter remaining in the extract. *Neuman.*

) YELLOW. A yellow dye may be made from indigo in the wing manner.

ake half an ounce of powdered indigo, mix it in a high glafs l with two ounces of ftrong fpirit of nitre, previoufly di- d with eight ounces of water. Let the mixture ftand for a k, and then digeft it in a fand-bath for an hour or more, and four ounces more of water to it; filter the folution, which be of a fine yellow color. Strong fpirit of nitre is apt to fet to indigo, and on that account it muft be diluted with water. o ounces and a half of ftrong fpirit of nitre, or lefs highly con- trated, will fet fire to half an ounce of indigo. The reafon of ing it ftand a week before the digeftion, is to prevent its hing up.

One part of the above folution mixed with four or five parts of er will dye cloth or filk from the paleft yellow color to the peft, by letting the ftuffs boil more or lefs in the color. The ition of alum makes the color more lafting.

Cochineal, Dutch litmus, orchel, cudbear, and many other oring fubftances treated in the manner as indigo is in the ove receipt, will all dye filk and wool of a yellow color.

Cloth and filk may be dyed green with indigo, by boiling firft the yellow and then in the blue.

Experiments on Aurum Mofaicum by Mr. P. Woulfe. *Phil. anf.* 61.

ZAFFRE,

Z A F F R E

ZAFFRE, *or* SAFFRE. Zaffre is the refidu
cobalt, after the fulphur, arfenic, and other
tile matters of this mineral have been expelled by ca
tion. It is therefore a kind of calx of cobalt, of a g
reddifh color. The ufe of cobalt is to produce a ve
blue color, when it is melted with fufible and vitr
matters.

This blue color produced by the vitrification of
proceeds from the earth or calx of a femi-metallic fub
contained in cobalt, called by chemifts, *regulus of*
This is proved by melting zaffre with a reducing flux
any other roafted ore; by which means the above-men
femi-metallic regulus of cobalt will be obtained.
fcoria in this fufion has alfo a blue color, which pr
from a portion of the calx of this regulus that is not red
but is vitrified along with the fcoria.

The calx, therefore, or metallic earth of the regu
cobalt, is the fole caufe of the blue color produced by z
But as the quantity of regulus contained in cobalt is
able, therefore fome zaffres furnifh more blue than o
The heterogeneous, fixed matters contained in co
contribute, according to their quantity, not only t
greater or lefs intenfity of the blue color, but alfo
luftre and beauty. For which reafon thofe who m
facture zaffre from cobalt make frequent effays o
roafted ore, by mixing it with vitreous matters to dif
the intenfity and beauty of the blue color.

Good cobalt calcined would form too deep a blue
almoft a black glafs, if it were not previoufly
with a certain quantity of vitreous fritt. In the m
facture of zaffre, therefore, the calx of cobalt, the ftr
of which has been previoufly determined by Effays, is m
with fuch a quantity of fand, or of powdered flint
quartz, that with the addition of fome faline flux, a
blue glafs may be formed.

The zaffre that is commonly fold, and which c
from Saxony, is a mixture of calx of cobalt with
vitrifiable earth, as we have faid. It is of a grey c
as all calxes of cobalt are before vitrification. Some z
are dearer than others, according to the intenfity o
color which they are capable of producing. Zaffre h
ployed in the manufacture of pottery and of porce
for painting the furface of the pieces of ware, upon w
it is applied together with fome faline flux, previou

aking or glazing, that the same fire may also vitrify
oloring material.
e blue of zaffre is the most solid and fixed of all the
that can be employed in vitrification. It suffers
ange from the most violent fire. It is successfully
yed to give shades of blue to enamels, and to the
l-glasses made in imitation of some opake and transpa-
precious stones, as the lapis lazuli, the turquois, the
re, and others of this kind. *See the articles* AZURE,
LT, INK (SYMPATHETIC), *and* SMALT.

EOLITES. *(a)*

ZINC.

ZEOLITES. This name is given by Mr. Cronstedt to a
lescribed by him in the *Transactions of the Academy of Sciences*
ckholm for the year 1756, the peculiar properties of which
nduced that mineralogist to consider it as forming a distinct
of earths, called *zeolites*. The properties of this stone or
f earths, are the following.

It is a little harder than the fluors, and calcareous spars. It
e scratched by steel, from which it does not elicit sparks.
It may be easily melted by heat without addition, into a
frothy slag, which not without great difficulty can be ren-
solid and transparent. Crystallized zeolites, when melted,
as borax does.
It may be dissolved in the fire more easily by mineral alkali
by borax or by the fusible salt of urine.
It does not effervesce with the fusible salt of urine, as calca-
stones do; nor with borax, as gypseous stones do.
It dissolves very slowly, and without effervescence, in acids,
oil of vitriol, and spirit of nitre. When concentrated vi-
c acid is poured on powdered zeolites, a heat arises, and the
er is changed into a gelatinous mass.
In the very moment of fusion it gives a phosphoric light.
olites has been found only in an indurated state. It is either,
nsisting of particles of no determinate form; or, 2. *sparry*; or,
stallized.
e zeolites that consists of particles of no determinate form,
her *pure* and white; (or it is *mixed with silver and iron*;
latter kind is of a blue color, and is commonly called lapis
i. *See* LAPIS LAZULI.
e *sparry zeolites* resembles calcareous spar, but is more
e. This is of a light red, or orange color.
ystallized zeolites. Groupes of crystals of zeolites are found
rm of white or yellow balls consisting of many pyramids the
s of which unite in the center; or of white prisms with trun-
l angles; or of white capillary crystals.

Zeolites

ZINC. Zinc is a ſemi-metal, of a brilliant
color, approaching to blue. It is the leaſt brittle o
ſemi-metals; and when well furniſhed with phlog
which may be affected by treating it with inflamn
matters in a cloſe veſſel, it poſſeſſes a ſemi-ductility
means of which it may be flattened into thin plates.

This property, joined to its hardneſs, which is
conſiderable, renders it incapable of being pulveriſed
the other ſemi-metals; therefore, when it is required
divided ſtate, it muſt be melted and granulated, or
like metals.

The ſpecific gravity of zinc is nearly the ſame as th
regulus of antimony; that is to ſay, it loſes in water a
a ſeventh part of its weight. (c)

This ſemi-metal is not eaſily calcined or covered
ruſt by the action of the air and of water: in this reſpe
reſembles tin. It is leſs fuſible than tin and lead,
does not melt till it is almoſt red-hot. When it only ſu
the degree of heat neceſſary for its fuſion, its ſurfac
calcined and reduced to a grey calx, eaſily reducible,
thoſe of tin and other fuſible metallic ſubſtances. But wh
is expoſed to a heat approaching to a white-heat, it flan
and during this inflammation it exhibits a very beau
and ſtriking appearance. The flame of zinc is infin
more lively, more luminous, and more brilliant, than
flame of any other inflammable matter. It is of a dazz
white, and is ſo vivid as to be inſupportable to the ſi
This flame cannot be attributed to any ſulphur w
might be ſuppoſed to remain united with the zinc,
we ſhall ſee that this ſemi-metal cannot be united
ſulphur; but merely to phlogiſton, which in zinc is
combuſtible. This ardent deflagration is a moſt ſen
proof of the preſence of this principle in metallic
ſtances.

Zeolites has in the fire nearly the ſame properties as boles l
See *Stockholm's Tranſ.* for the year 1755, and *Cronſtedt's M
ralogy*, §. 108.

(*b*) Zinc when broken appears of many flat, ſhining plate
facets, which are larger when ſlowly than when haſtily coo
When heated, it is very brittle. Like tin, it makes a crack
noiſe when it is bent.

(*c*) According to Muſchenbroek's Table of Specific Gravi
Indian zinc is to water as 7.2401 to 1: and zinc of Goſlar
7.215 to 1.

e deflagration of zinc is ſo violent, that the earth is ſemi-metal, although naturally very fixed, like f almoſt all metallic ſubſtances, is raiſed in form of ſmoke, which is condenſed, and floats in the air like flocks. Theſe are called *flowers of zinc*, and *philoſophi-ol. See* FLOWERS *of* ZINC.

nc being the moſt combuſtible of all metals, detonates violently than any other metal with nitre. From hiteneſs and brilliancy of the flame produced by this ation, it has been employed with very good effect as gredient in compoſitions for fire-works.

acids are capable of diſſolving zinc. Six parts of vitriolic acid diluted with an equal weight of water can e entirely, by help of gentle heat, one part of zinc. neutral ſalt reſulting from this ſolution is cryſtallizable; s called *white vitriol*, or *vitriol of zinc. See a deſcrip- the method in which this vitriol is made at Goſlar, at the* SMELTING *of* ORES.

nc has a ſtrong affinity with vitriolic acid. It appears e a ſtronger than any other metallic ſubſtance: for ans of this ſemi-metal the vitriols of copper and of may be decompoſed. It ſeparates theſe metals from triolic acid, to which it unites and forms a white . But what is remarkable, is, that notwithſtanding reat affinity of zinc with vitriolic acid, the vitriol of is decompoſed, and its acid ſeparated by leſs heat he martial vitriol, as Junker affirms in the firſt volume *Conſpectus Chymiæ*. If this experiment ſucceeds, as bly it does, we muſt refer the cauſe of it to the particular of the inflammable principle in zinc and in iron. All roperties of theſe two metallic ſubſtances ſhew that abound in phlogiſton, and therefore vitriolic acid with them preferably to any other. But, at the ſame this phlogiſton is in theſe metals much unfolded and y combined, which is undoubtedly the cauſe, that eutral ſalts which they form with the vitriolic acid e decompoſed by the action of fire. For the phlo- of theſe metals adhering but ſlightly to their earth, be more eaſily combined with the vitriolic acid, and onverting this acid into volatile vitriolic, or ſul- ous acid, may ſtill more facilitate its ſeparation.

t as the inflammable principle of zinc is more abundant, nore ſlightly engaged than that of iron, zinc ought ite with vitriolic acid preferably to iron, and the l of zinc ought to be decompoſed by fire more eaſily the vitriol of iron.

When white vitriol is diſtilled by violent heat, the ſame phenomena happen as when martial vit diſtilled. Towards the end of the diſtillation of vitriol, a vitriolic acid ariſes, dephlegmated, thoug ſulphureous. This acid, added to common conce vitriolic acid, produces as much heat as water woul done if added to the ſame concentrated acid.

Zinc may alſo be diſſolved in the nitrous and acids. But this latter acid does not touch a black which ſeparates from the ſemi-metal during its ſo M. Hellot, who has examined the phenomena of th tion as well as thoſe of the ſolutions of this ſem in the vitriolic and nitrous acids, has aſcertained th black matter is not mercury, and that it cannot reduced into a metallic ſubſtance. (*d*)

Zinc may be allayed or mixed with all metallic ſub excepting *biſmuth* (*e*). If theſe two metals be melted to they will be found ſeparately at the bottom of the cr the zinc, being the lighter, lying above the biſmuth allay of zinc with iron is effected difficultly; bu with copper ſucceeds well, and is much uſed, on of a ſingular property which zinc has of unitin copper in a conſiderable proportion, as, for inſtan part of zinc to four or three parts of copper, much diminution of the ductility of copper. Zin to copper renders this metal leſs ſubject to ruſt, an to it a yellow color reſembling that of gold. This ſo allayed with zinc is called *braſs* or *latten*. *See* BR

The color of braſs approaching to that of gold, duced chemiſts to ſearch for the means of commun to copper the true color of gold; and they have ſucceeded in the compoſitions or allays called *tomba lor*, *Pinchbeck*, and *Prince's metal*. Becher had ſai equal parts of copper and zinc mixed together gave to the touch-ſtone like that of the gold from the Stahl remarks that the proportion of zinc mentio Becher is too great, but does not determine wh proportion ought to be. Since that time, the due tion has been inveſtigated, and ſeveral fine imitat gold have been found. The Engliſh were the fi ſucceeded, and they called their invention *Prince'* or *Prince Rupert's metal*.

(*d*) Neuman ſays, that this black matter was ſeparate the ſolution of this ſemi-metal in vitriolic and in mari and that two or three days afterwards it was re-diſſolved.

(*e*) It cannot be allayed with the ſemi-metal called ni

re perfect imitations of gold have been lately made
croix and Leblanc; each of whom produced a me-
mixture, one of which excelled in ductility, and
her in color. But these artists have not revealed their
ses. M. Geoffroy has made with this view many ex-
nts, the detail of which may be seen in the Memoirs
Academy for the year 1725. It appears from these
ments, that the remark made by Stahl, that an equal
ty of zinc is too much, was very just, with regard to
ctility of the allay, but that equal quantities pro-
the finest color. We may nevertheless observe, that
per requires a strong heat to keep it fused, and as
s very volatile, these two substances cannot be mixed
it loss, both of the copper, some of which is calcined,
f the zinc, a part of which is burnt and dissipated
nes. Hence it follows, that after the mixture is
the proportion betwixt the two metals is not certain.
some experiments which I have seen, I can scarcely
suaded that a fine-colored mixture can be obtained,
rticularly of a deep enough yellow, if as much zinc
per actually remained. (*f*)

must also observe, that in order to have a fine-colored
uctile metallic mixture of this kind, it is necessary,
ling to Mr. Cramer, to use the purest zinc. The
uthor shews the means of purifying it, and of ascer-
g its purity. This method is founded on the re-
ble property which zinc has of being incapable of
g with sulphur (*g*). Therefore, to purify this semi-
from the allay of other metals, it is necessary to
upon it, when melted in a large crucible, suet and

One part of zinc is said to be capable of destroying the duc-
of a hundred parts of gold. An allay of equal parts of
nd gold is very hard, white, capable of receiving a fine po-
nd not subject to rust or tarnish: hence it is proposed by
Halouin as a good material for making specula of telescopes.
gives hardness to tin, and is therefore added in some com-
ns for making pewter.

Mr. Cramer says that zinc does not easily unite with sul-
but that if it remains long in a moderate fire, and be co-
over with sulphur at several times, and continually stirred
poker, it will be at last changed into a very brittle, dark-
d substance. I suspect that the iron of the poker contri-
to this union of zinc with sulphur, for I have never been
o unite sulphur with pure zinc, when I stirred them with a
co-pipe.

sulp.

ſulphur alternately, and the latter in larger quan
the former. If the zinc is pure, the ſulphur burns
its ſurface; but if it is allayed, the ſulphur combine
other metals, and forms with them a kind of ſcoria w
be taken off. This alternate projection of ſuet ar
upon zinc is continued till the ſulphur be burnt o
face of the melted zinc without forming any ſc
zinc thus purified, may be ſucceſsfully employed f
of braſs or metallic mixtures in imitation of gold.

The affinities of zinc are, according to Mr.
Table, in the following order: Copper, iron, ſil
tin, and lead. This laſt is ſaid to be only partl
with zinc. Sulphur might be ſo placed in this
to ſhew its incapacity of uniting with zinc.

The chief uſe of zinc is as an ingredient in th
ſition of braſs. M. Malouin, who, in his Mem
Zinc, has mentioned ſeveral properties of this ſ
which he finds analogous to thoſe of tin, relate
Memoirs ſome experiments which he made with
in order to ſubſtitute zinc for tin, in the opera
iron plates, &c. called *tinning*. As all the propert
ſemi-metal are not yet diſcovered, it may perhaps
after found applicable to other uſes. *(h)*

(h) Some authors, as Wallerius and Cronſtedt,
filings of zinc are attracted by magnets. I have not b
obſerve this property.

Zinc unites more ſtrongly to acids than any other
even ſome earths. Mr. Pott ſays, that it precipitates
baſis from a ſolution of alum; and that zinc cannot be p
from aqua-fortis by crabs eyes. He alſo ſays, that
precipitated by volatile alkali, but that this precipitate
re-diſſolved.

The ſame author ſays, that zinc, by being conv
flowers, acquires an additional weight, equal to $\frac{1}{10}$th
ſemi-metal employed.

Mr. Malouin relates, that zinc being melted ſix time
fuſion continued 15 hours each time, it became more
hard, brittle, unfuſible, and uncalcinable. He ſays
color became grey after the ſecond fuſion, brown after
black after the fourth, blue like a ſlate after the fifth,
violet-color after the ſixth.

Concerning the ores and eſſay of ores of zinc, *ſee*
ZINC; and concerning the methods of extracting large
of this ſemi-metal from its ores, *ſee* SMELTING *of* C
PLATE II. *Fig.* 15, *and* 22, *with the explanations.*

FINIS.

N

S.

ere the beſt

torts.

›pple.

Fig.

EXPLANATION

OF THE

LATES.

PLATE I.

1. A Retort. *See* also *Fig.* 12. A. where the best form of a Retort is shewn.
   A, Its belly or bowl.
   B, Its neck.
2. Retorts of this form are called *English Retorts.*
3. A Glass Alembic.
   A, The cucurbit.
   B, The head.
   C, The gutter within the head.
   D, The beak.
4. A Long-Necked Glass Alembic.
   A, The body of the matrass.
   B, The neck of the matrass.
   C, The head of the alembic.
5. A Glass Alembic *consisting of one Piece.*
   A, The cucurbit.
   B, The head.
   C, The aperture in the head.
   D, Its stopple.
   E, The mouth of the cucurbit.
6. A Pelican.
   A, The cucurbit.
   B, The head.
   C, The aperture in the head with its stopple.
   D, The two curved spouts.
7. A Row *of* Aludels.

FIG. 8. A COPPER ALEMBIC.

A, The body or cucurbit.
B, The neck.
C, The head.
D, The beak, nose, or spout.
E, The refrigeratory or cooler.
F, Its cock.
G, The receiver.

FIG. 9. A MUFFLE.

FIG. 10. *A perpendicular section of a* CUPPEL *or* T[...] The curve line represents the cavity that contains [...] metal. The plan or any horizontal section of a cupp[...] a circle.

FIG. 11. AN INGOT-MOULD, into the cavities of w[...] melted metals are poured.

FIG. 12. AN APPARATUS *for* DISTILLING, by w[...] the vapors that usually escape in the ordinary metho[...] distillation, are condensed by passing into water or [...] other fluid. This apparatus was invented and describe[...] by Mr. Peter Woulfe. *See the Phil. Trans. Vol.* LVII.

A, A retort. Instead of this retort, in the distillatio[...] some substances, may be substituted an iron pot wi[...] stone-ware head, the neck of which is to be inserted [...] the receiver, as in the present Figure.

B, A receiver, with a neck, into which the neck of [...] retort is to be inserted; and a spout at its bottom, thr[...] which the distilled liquor passes into the bottle C; [...] an opening in the side at D, into which one end of a [...] bent at right angles is inserted. The other end of this [...] passes into a vessel H, open at both ends, the l[...] opening of which is closed with a glass stopple. Thr[...] the upper mouth of the vessel H, one end of another tu[...] bent twice at right angles, passes, while the other end of [...] tube is inserted into a bottle F, and immersed in the wat[...] other fluid contained in that bottle. The crooked t[...] are fitted into the mouth of the vessel H by means of a c[...] in which are two semi-circular notches, through which [...] tubes pass, and by lute.

The tube which passes into the bottle F is fitted into [...] mouth of this bottle by means of a cork, in which is a s[...] circular notch. This mouth of the bottle F is not cl[...] with lute.

The vapor that is raised from the substance expose[...] heat in the retort passes into the receiver B, where pa[...] it is condensed, and flows into the bottle C, while the[...]

passes through the tube at D, into the vessel H. this vessel, the vapor that still remains uncondensed through the crooked tube I, into the water con- in the bottle F, by which it is all condensed except- me elastic air, which is extricated in almost all tions. This elastic air arises through the water, capes at the semi-circular notch of the cork in the of the vessel, which is therefore not accurately closed .

most distillations a quantity of air is absorbed at different during the process: and in this case the external air ess on the liquor in the bottle F, and force it through e I into the vessel H, from which it may be taken by g the stopple L.

use of the vessel H is to receive the liquor that may s raised from the bottle F, and to prevent it from into the receiver B, and from thence into the C, where it might spoil the distilled liquor.

Woulfe, in the above-mentioned Philosophical ctions, relates several experiments made with this tus, from which the utility of this method of con- vapors by making them pass into water, or some luid suited to the nature of the liquor distilled, ap-

s, by distilling twelve pounds of sal ammoniac with me and two gallons of water, he obtained eight and a quarter of volatile alkaline spirit sufficiently to make eau de luce, which were collected in the joined to the receiver; and upon adding two other of water, he obtained seven pounds of weak volatile e spirit. The water contained in the bottle F, was six quarts, received an encrease of 2½ lb. in from the vapor condensed in it; and from experi- made to compare the strength of the alkali thus sed by the water with that of the strongest alkaline first obtained, and which we have said was fit king eau de luce, it was found, that the strength of rmer was to that of the latter as 140 to 76: hence antity saved by this apparatus was nearly equal to ounds of volatile alkali sufficiently strong for making luce. Mr. Woulfe observed a singular difference t the alkaline liquor collected in the bottle joined receiver, and that which was condensed in the water bottle F, namely, that a considerable heat was

 excited

excited by mixing the latter alkaline ſpirit, but n
former with vitriolic acid.

Another experiment is related, of the diſtillati
twelve pounds Averdupoiſe of common ſalt with an
quantity of oil of vitriol diluted with 7 lb. of wate
this operation 9 lb. 5 $\frac{1}{2}$ oz. of ſpirit of ſalt were co
in the bottle C, and 6 lb. 12 $\frac{1}{2}$ oz. of the ſame ſpiri
condenſed in ſix quarts of water in the bottle F.
reſiduum weighed 18 lb. 6 oz. Hence in this ope
there was a loſs of eight ounces, or $\frac{1}{70}$th part of the
moſt of which probably was elaſtic air. The ſtren
the acid condenſed in the water was found, by exper
to be to the ſtrength of the acid collected in the bo
as 200 is to 109. Theſe vapors, condenſed in water
found to be more concentrated when the diſtillatio
conducted ſlowly than when it was haſtened. It ap
alſo, that the moſt concentrated portion of the acid
ſalt is the moſt volatile, and that its ſtrength was to
vitriolic acid (the ſpecific gravity of which was to
water as 24 to 13), as 44 $\frac{1}{4}$ to 31. Experiments alſo ſ
that this vapor of ſpirit of ſalt condenſed in wate
tained no vitriolic acid, although the ſpirit collected
bottle C did contain ſome of that acid.

The ſame ingenious chemiſt formed a *marine et*
applying the vapor of rectified ſpirit of wine to th
concentrated vapor of marine acid, and by condenſi
united vapors in ſpirit of wine. This he effected by
contrived apparatus. The necks of two retorts,
which contained the ſpirit of wine, and the other t
ſalt and vitriolic acid, from which the marine acid
be diſtilled, opened into one receiver, where the
met: from this receiver the vapors paſſed through
into ſpirit of wine, contained in a bottle; and thoſe
were not there condenſed paſſed through another tu
ſpirit of wine contained in a ſecond bottle. By a furthe
lation and cohobation, with ſlaked lime, of the ſeveral
collected in the receiver and in the ſpirit of wine in
the vapors were condenſed, a very ſubtle penetrating
was produced. Mr. Beaumé had tried to procure a
ether by uniting the vapors of the marine acid, and o
of wine; but he failed, becauſe he did not uſe an e
method of condenſing the vapors.

Mr. Woulfe did not find that much advanta
gained by this method of condenſing vapors in water,
diſtillation of the nitrous acid from nitre mixed with v

e prevented

ion may be
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ole ; to the
which ſub-
ater ; to the
he vapors of
and, laſtly,

This figure
: copied from
Engliſh Edi-

owing man-
quadrangular
h ($a\ a$, $b\ b$,)
id ($b\ b$, $c\ c$),
at top ſeven
bottom with
bottom to it
three inches
aſh-hole. 3.
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heſe muſt be
n-plate ($h\ h$),
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5

excepting that thus the noxious fumes are prevented hurting the operators.

thinks his propofed method of condenfation may be cable to the diftillation of vitriolic acid, the fulphu- fumes of which are difficultly condenfible; to the fication of phophorus, the vapor of both which fub- es ought to be condenfed by means of watei; to the fication or diftillation of vitriolic ether, the vapors of h ought to be condenfed in fpirit of wine; and, laftly, any other diftillations.

PLATE II.

IG 1. *An* ESSAY *or* CUPELLING FURNACE. This figure the following defcription of this furnace are copied from ner's *Art of Affaying. See Dr. Mortimer's Englifh Edi- p.* 75.

The affaying furnace is made in the following man- 1. Make with iron plates a hollow quadrangular n, eleven inches broad and nine inches high (*a a*, *b b*,) ng at top in a hollow quadrangular pyramid (*b b*, *c c*), inches high, terminating in an aperture at top feven es fquare. This prifm muft be clofed at bottom with her iron plate, which ferves as a bafis or bottom to it . 2. Near the bottom make a door (*e*) three inches , and five inches broad, that leads to the afh-hole. 3. e this door, and, at the height of fix inches from the , make another door (*f*), of the figure of a fegment circle, four inches broad at its bafis, and three inches half high in the middle. 4. Then faften three iron s on the forepart of this furnace; let the firft of them , eleven inches long and half an inch high, be faften- o that its lower edge fhall reft againft the bottom of the ce, with three or four rivets, and in fuch a manner, there may be between the upper edge of the faid plate the fide of the furnace a groove fo wide, as that the s of the lower door (*k k*) may be put into it, and free- ove backwards and forwards therein: thefe muft be of a thicker iron-plate. The fecond iron-plate (*h h*), n inches long, three inches high, and perfectly paral- the foregoing plate, muft be faftened in the fpace be- n the two doors, in fuch manner, that both the upper he lower edge of it may form a hollow groove with the fide

fide of the furnace. One of thefe grooves, which is ed downwards, ferves to receive the upper edges o fliders that fhut the lower door (No. 2). The other, turns upwards, is to receive the inferior edges of the f of the fmall door above (No. 3). The third plate which is like the firft, muft be rivetted clofe above the door, in fuch manner, that it may form a groove tu downwards, and contiguous to the upper edge of the door (No. 3). 5. In order to fhut both doors (No 3), you muft adapt to each of them two fliders ma iron-plates, that may move within the above-ment grooves (*k k*, *l l*); but the two fliders belonging to the door (No. 3.) muft have each a hole near the top; th one a fmall hole one fifth part of an inch broad, an inch and a half long (*m*); and the other a femi-cir aperture, one inch high and two inches broad (*n*). Let fides, each flider have a handle, that they may be laid of when they are to be moved. 6. Moreover, let round holes, one inch broad, be bored in the furnace, of which muft be made in the fore-part of the furnace two others in the back-part, all at the height of five in from the bottom, but three inches and a half diftant each fide, of the furnace; and, finally, a fifth hole (*p* the height of one inch above the upper edge of the door (*f*). 7. In fhort, let the infide of the furnac armed with iron-hooks, jetting out half an inch, and a three inches diftant from each other, to faften the lute which the furnace is to be covered over within. 8. then an iron, moveable, hollow, quadrangular pyramic three inches high, be adapted to the upper aperture (the furnace, at the bafis feven inches broad, ending wards in a hollow tube (*r*), three inches in diameter, inches high, almoft cylindrical, though fomewhat co gent at top. This prominent tube ferves to fupport a nel or flue, which is almoft cylindrical, hollow, ma iron-plates, and two foot high, and which, when a ftrong fire is required, is put perpendicularly upon fhorter tube, in fuch manner, that it enters clofe in one inch and a half, or two inches deep, and may aga taken off at pleafure, when there is no need of fo ftro fire. But this pyramidal cover (*q*) muft befides have handles (*s s*) adapted to it, that it may be laid hold of, thus be taken away or put on again: and that this, put on the aperture (*d*) of the furnace, may not be thrown down, let an iron plate be rivetted to the righ

upper edge of the furnace (c c), and be turned down
ards the inside, so as to make a furrow open before
behind, into which the lateral edges of the cover may
er and be fastened, and at pleasure be moved backwards
forwards, whenever it must be put on, or moved. 9.
a square ledge, made of a thick iron-plate, be fastened
op of the upper edge of the lower door (e); this is de-
ed to support the grate and the lute: but it must be
le of two pieces, that it may be easily introduced into
cavity of the furnace. Thus you will have an assay-
n, which must afterwards be covered over on the inside
h lute. This you are to do as follows:

' That the fire may be better confined, and that the
may not be destroyed by growing red-hot, the whole
de of the furnace must be covered over with lute, one
er or one finger and a half thick. The lute fit for this
nade of a mass of clay mixed with sand, and moistened
h three or four times as much of ox-blood diluted with
er *. But before you cover the inside of your furnace
h this lute, you must first put within the furnace small
bars, equal in length to the diameter of the oven,

The best lute, and easiest to be had at London, is a sort of
called Windsor loam, which must be mixt pretty stiff, and
sed into the inside of the furnace, first wetted with water; and
n the clay begins to dry, it must be beat down close to the
s with a wooden mallet; then the unevenness and cracks
d up with fresh clay somewhat moister, so as to be made
oth and even with a trowel, and then left to dry gently; and
ny cracks happen, they must again be filled up. *Note of Dr.
timer.*

tourbridge clay, tobacco-pipe clay, or any other pure clay that
ot fusible by fire, may be used for this purpose. But as fresh
shrinks and cracks very much in drying, it ought to be mixed
an equal quantity or more of coarse white sand, or of burnt
grossly powdered. Thus one part of Stourbridge clay, one part
oarse white sand, and one part of Stourbridge bricks grossly
dered, being well mixed together, make a good lute for lining
inner surfaces of furnaces. To prevent the iron plates of the
aces more effectually from calcination, their inner surfaces
ht to be covered with a coating of charcoal-powder formed into
ass or paste, with as much fresh clay and water as are sufficient
that purpose; and when this coating is dry, the above-men-
ed lute may be applied. During the drying the lute ought to
laily beat with a mallet, that the spaces left by the shrinking
he clay may be closed, and the lute be rendered more compact.

quadrangular,

quadranglar, prismatical, half an inch thick, having
extremities supported by a square iron ledge, and t
fourths of an inch distant from each other; and you
fasten them so, that their flat sides may be oblique
regard to the transverse section of the furnace, and tha
two opposite angles may look one upwards and the
downwards; the bars must not be laid flat, but edge-
by which situation you hinder the ashes of the fuel of th
from being detained too long between the interstices o
said iron-bars, and from making an obstruction that
oppose the free draught of the air. The furnace being
covered over with lute, and dried up by a gentle he
at last fit for docimastical operations, and especiall
such as must be performed in the assay-oven.

If then an operation is to be made in the furnace hit
described, you must let through the four lower holes
described, of the furnace (*oo*) placed before and be
and directly opposite to each other, two iron-bars one
thick, and long enough that their extremities on ever
may jut out of the holes a small matter. These se
support the muffle and its bottom (*See* Plate I. FIG
You then introduce the muffle through the upper ap
of the furnace (*d*), and place it upon the above-desc
iron-bars, in such manner, that the open fore-side
be contiguous to the inward border of the upper doo
The fuel of the fire is introduced through the top o
furnace (*d*); the cover of which, on this account,
be moveable and not very heavy (*q*). The best fuel f
fire is charcoal made of the hardest wood, especial
beech, broken into small pieces of the bigness of an
wherewith the muffle must be covered over some i
high. We then reject larger bits of coals, becaus
cannot fall through the narrow interstices, betwee
sides of the muffle and those of the furnace, and cann
course sufficiently surround the circumference of the m
Whence it happens, that there are on every side place
of fuel, and the fire is either not strong enough or un
But if, on the contrary, you use coals too small,
great part fall immediately through the interstices
grate into the ash-hole; and the tenderest particles of
turn too soon into *ashes*, and by increasing the he
ashes, obstruct the free draught of the air, which i
greatly requisite.

" A perfect management of the fire is most com
necessary in the performing of operations in this fur
the

refore the reader muſt give attention to what follows: If door of the aſh-hole (*e*) is quite open; and the ſliders of upper door (*f*) drawn towards each other, ſo as to touch another in the middle of the door; and if, beſides, cover (*q*), and the funnel adapted to its tube (*r*), is on the top (*q*) of the furnace, the fire will be then in the heſt degree poſſible; though, in the mean time, it is hard-ever neceſſary to put the funnel on, except in a very cold ſon: but if, after having diſpoſed the furnace in the nner juſt deſcribed, you put red burning coals into the en upper door (*f*) of it, the fire is ſtill more increaſed reby: however, this artifice is never, or very ſeldom, eſſary. When you ſhut the upper door with only that er that has a narrow oblong hole in it (*m*), then the t becomes a little leſs; but it diminiſhes ſtill more when ı ſhut the door with the other ſlider that has in it the ni-circular hole (*n*), which is larger than that of the firſt er: nay, the heat again is leſs when you take away the nel put at top of the cover: finally, the door of the -hole being either in part or totally ſhut, the heat is ſtill ninifhed, becauſe the draught of the air, ſo neceſſary to ite the fire, is thereby hindered: but if, beſides all theſe, ı likewiſe open the upper door quite, then the cold air, hing into the muffle, cools the bodies put under it, that to be changed, to a degree never required in any ope-ion, and ſuch as will entirely hinder the boiling of lead. during the operation, the fire begins to decay, or to w unequal, it is a ſign that there are places void of ls between the ſides of the furnace and thoſe of the ffle; therefore, in this caſe, you muſt ſtir your coals on ry ſide with an iron-rod, which is to be introduced ough the upper hole (*p*) of the furnace, that they may l together, and thus act in a proper manner and equally.

" However, you are to obſerve concerning the regimen the fire juſt deſcribed, that though the *apparatus* is made th all the exactneſs mentioned, nevertheleſs the effect es not always anſwer it. The cauſe of which difference s moſt commonly its origin in the various diſpoſitions of air; for as every fire is more excited by coals in pro-tion as the air, more condenſed, and more quickly tated, ſtrikes them more violently (which the effect of lows plainly ſhews); it thence appears, that in warm l wet weathers, when the atmoſphere is light, the fire ſt be leſs efficacious in furnaces; that likewiſe when ſeve- furnaces, ſituated near each other, are burning at the ſame time,

time, the fire is in part suffocated; because the ambie
is thereby rendered more rare and lighter. The same
is produced by the sun, especially in summer-time, w
shines upon the place where the furnace is situated.
atmosphere, on the contrary, being heavier in co
weather, excites a very great fire.

"The heat of the fire acts the stronger upon the
to be changed, as the muffle put in the furnace is les
the said muffle has more and larger segments cut out
as the sides of this muffle are thinner; in short, as
are more vessels placed in the hinder part of the m
and on the contrary. In this case, when many
conditions requisite for the exciting of fire are wa
then indeed the artificer, with all his skill, will har
able to excite the fire to a sufficient degree, in order t
form operations well, in common assay-ovens, even t
he uses bellows, and puts coals into the upper door
furnace. For this reason, I have put the grate almost
inches below the muffle, lest the air, rushing throug
ash-hole, should cool the bottom of the muffle,
happens in common assay-ovens; and again, tha
smaller coals, almost already consumed, and the ashes
more easily fall through the interstices of the grate, a
larger coals still fit to keep up the fire be retained. Fi
I have added the above-mentioned funnel, that the bl
of the fire being, by means of it, increased as much a
sible, this might at last be carried to the requisite de
for the fire may always be diminished, but not alw
increased at pleasure, without the assistance of a prop
paratus."

FIG. 2. This figure represents a furnace call
ATHANOR. *See* ATHANOR. This figure and the fo
ing description are copied from *Cramer*'s *Art of A*
"This furnace is used for the distillation of acid
for calcinations, cementations, &c. As these oper
require a long and constant fire, an athanor is usefu
cause it can contain as much fresh fuel as will keep
fire for many hours together, and admits of a differe
accurate, and most constant regimen of the fire.

"Let then, 1st, a small square hollow tower *(a*
be constructed of such *stones*, [or of bricks made of
bridge clay, or *Windsor loam*,] as may resist the fire;
sides of it be six inches thick, and forming a square
within, of ten inches on each side *(b b b b)*. The
of it is determined according as it is to keep up the fire

w

hout any addition of new fuel: five or six feet are most
nmonly sufficient. 2. At the bottom of this tower
ke an opening (c), six inches broad, and as many inches
h; hang to it an iron door, being on every side one inch
ader than the opening, and such as may shut it very
se: for which purpose the external edge of this opening
st be excavated all round in such a manner, that it may
m a groove one inch broad, into which the edges of the
r may be received. 3. At the distance of ten inches
m the bottom of the tower, put a grate (d), made of
smatical, quadrangular iron-bars, one inch thick, and
ee quarters of an inch distant from each other: let also
h of these iron bars be so situated with regard of the
ver, that the two opposite acute edges of each may look
pendicularly, one downward, the other upwards, that,
this means, the ashes may easily fall into the ash-hole.
Make above this grate an opening circular at top (e)
inches high, seven inches broad, that may, as well as
ash-hole (No. 2), be opened and shut with an iron-door.
Adapt to the top of the tower an iron cover (f), exceed-
the aperture of the tower all around two inches, and
ving a handle, wherewith it may be easily taken away,
l put on again. Thus you are to make the furnace
led in Latin *furnus primarius*. 6. Then cut out in any
e of the tower, for instance, in the left, an oblong square
erture, going up obliquely towards the outside (g g),
r inches and a half high, ten inches broad, having its
ward inferior edge one inch and a half, or two inches
ove the grate (d); that by the intervening of this hole,
cavity of this tower may communicate with another im-
diately to be described. 7. Nearly over-against the
ne side of the tower, make a cavity with stones, whose
erior part must be a hollow prism (h, h, h, h,) six
hes high, twelve inches broad, ending at top in a semi-
lindrical arch (i, i,) described by a *radius* of six inches;
t by this means, the height of the whole cavity may be
elve inches in the middle. Let this anterior cavity be
ally open, though, when requisite, it is to be shut very
se with an iron plate (k, k,) whose inward surface is to be
nstructed in the same manner as is prescribed for the sliding
or of the melting-furnace, (FIG. 4.) and then luted two
hes thick within. Moreover, let there be in the middle
this plate, a round hole, four or five inches in diameter,
d let the circumference of this hole have an iron cylin-
cal border made to it, and prominent within; that by
means

means of it, the lining of lute within may be suppo
and kept from falling down easily. Let a notch one
broad, and two inches deep, be made in the outward ci
of the aperture of this cavity, to receive the extremi
the plate that shuts the aperture. The hole of this
either is shut with a stopple, or serves to pass the nec
the retort through. This plate likewise is fastened with
bolts (*n*, *n*,), to be put horizontally with iron h
(*o*, *o*, *o*, *o*,) driven into the wall near the edge of the apertu
that one bolt may fasten the upper part of the plate, and
other the lower. 8. It is moreover proper, that the sq
aperture (*g*, *g*,) through which the fire enters from
tower into the cavity hitherto described (No. 7.), ma
shut and opened at pleasure with an iron slider: for if th
not done, an excessive fire, employed sometimes by an
experienced hand, cannot be so easily checked. For
purpose, let a slit half an inch broad, and eleven in
long, be left in the wall that constitutes the upper
of the cavity (No. 7.), and is contiguous to the tow
so that it may exceed the length of the square a
ture, (*g*, *g*,) a small matter on every side, and r
before and behind into the small groove, going down a
the perpendicular sides of the said aperture, (*g*, *g*,)
retain the iron-slider to be put into it to keep it ste
However, let this iron-slider be six lines thick, el
inches broad, and five inches high; and let a coupl
small iron-chains (*p*, *p*,) be fastened on each side o
upper edge, wherewith the slider may be lifted up and
down again. Therefore let a couple of strong iron-nail
drove into the contiguous wall of the tower, perpendicu
over those places in which the said small chains are faste
to the iron-slider, that any of the links of the chains
be suspended on them at pleasure. Moreover, let the u
edge of the slit above described be entirely shut up w
stones and cement, leaving only two small holes thro
which the small chains may be passed. On the left of
cavity (No. 7.), and at the distance of eight inches f
the bottom of it, let a square (*q*, *q*, *q*, *q*,) chimney or fun
be erected with *bricks*, three inches and a half in the cl
four foot high, and a small matter convergent upwards
that the diameter of it at top may be three inches. T
funnel must be contrived to be shut closely with an ir
slider, having a handle to it (*r*, *r*,), which slider must m
freely between a double iron square frame fastened in
walls of the funnel, at such a height from the he

ll feem convenient to any artificer. 10. Below this
ney let a fquare aperture be made, like the foregoing
6. *g*, *g*,), leading obliquely up to the bottom of another
lrical cavity, (*u*, *u*, *u*, *u*,) which is eight inches
defcribed by a *radius* of fix inches, open at top, and
converging inwardly into a border one inch thick,
x lines broad, defigned to fupport an iron-pot. Like-
cut in the anterior wall of this cavity, and at the
part of its mouth, a fegment two inches and a half
five inches broad, and ftooping forward (*v*, *v*,) to
e the neck of the retort. 11. To this cavity (No. 10.)
s an iron-pot (*w*, *w*,) eleven inches broad, and
nine inches deep, which muft be encompaffed with
n ring (*x*, *x*,) one inch broad, and faftened at the
e of one inch and a half from the upper end of the
Let a fegment (*y*) be likewife cut off the upper edge
pot, which fegment muft be four inches and a half
and five inches broad: the iron-ring juft defcribed
e bent all round the edges of this fegment. 12. Over-
the aperture (*t*, *t*,) which communicates from the
vity (No. 7.) into the fecond (No. 10.), let another
perture (*z*) be made, two inches diftant from the
of the fecond cavity (No. 10.) perfectly like the
ng (*g*, *g*, *t*, *t*,) and communicating obliquely up-
with a third cavity (1, 1, 1, 1,), like and equal to
cond cylindrical cavity (*u*, *u*, *u*, *u*,); that the fire
fs from the latter into the former. 13. In the hinder
f the wall which makes the aperture juft men-
(*z*), let a chimney like the foregoing (*q*, *q*, *q*, *q*,),
the fame height (2, 2, 2, 2,), be erected, which may
with a flider like that (3). 14. Finally, on the left
the third cavity let an aperture be made in the fame
r (4), and like the foregoing ones (*g g t t z*); more
however from the bottom of the cavity, without a
at the other extremity, and communicating only
he cavity of the third chimney (5, 5, 5,), which
e erected in the fame manner as the two foregoing
, *q*, *q*, *q*, 2, 2, 2, 2,). Thus you will have a furnace
oper for a great many operations.

Ve are now to fpeak of the ufe of the *athanor* juft
ed; and chiefly to mention, to what operations each
parts ferve in particular, and then how the fire may
uft be governed in it. 1. You muft put at the
arched door (*e*) of the tower a femi-cylindrical muffle
inches long, which muft be introduced through

the door: which for this reason must be of the same height and breadth as that door, three quarters of an inch thick, and open behind, being shut there by the hinder part of the athanor, as far as which it must reach. For this purpose, a *tile* must be set upon the grate *(d)* to support the muffle. Let also this muffle have small pieces cut out near its basis, as common assay-muffles. You may put under this muffle your cement pots, or such bodies as must be calcined with a long and violent fire; which can be done without a muffle, though not so neatly. 2. In the first chamber *(h, h, h, h, i, i,)* you may make the most violent distillations with an open fire: for retorts or large vessels are introduced into it, after you have taken away the door *(k, k, k,)*, and are put either upon the hearth itself of this chamber, or upon a particular support of stone. But you must place these vessels in such manner, that their necks may easily pass through the hole of the door, when put on again: for which purpose, they chuse a support sometimes higher, sometimes lower, according to the different heights of the vessels. When afterwards, the door is put on again, and fastened with both its bolts *(n, n,)*, you must close with lute all the chinks which lie open about the neck of the vessel, and between the edges of the door and the entrance of the chamber. Then you apply to the neck of the vessel a cylindrical segment, ten or more inches long: by means of which the heat and the boiling vapors coming forth are gradually diminished; lest the recipient, which is always chosen a glass vessel, should split. The recipient, which must be united with the other orifice of the said segment, is supported either by the pavement, or by a certain kind of trivet, the construction of which is such, that it may be set lower or higher by means of three screws. 3. In this same chamber, instead of distillations, you may also make cementations, calcination, &c. in which case the round hole of the iron-plate may be shut and again opened with a stopple, that one may view the inside. 4. The second and third cavities *(u, u, u, u, 1, 1, 1, 1,)* serve chiefly to such operations as are made in baths [or beds] of *sand*, *ashes*, or *filings*. For instance, you put into each of these cavities a pot, *(v, v,)*, and you stop with thin *lute* or with *sand*, which must previously be moistened, the slip between the iron-ring *(x, x,)* and the border of the cavity, upon which this ring rests. 5. Besides, you may also make in these two cavities, distillations by a reverberating fire, as well as in the first: only the fire is less violent

t in these, though sufficient to extract aqua fortis. hen take out the iron-pot (v, v,) and inverting it, it it upon the mouth of the chamber; so that the f the pot, being the depth of one inch and a half above on-ring (x, x,) wherewith this pot is surrounded, e received within the mouth of the cavity, and so he segment cut in the pot *(y)* may, together with gment cut out from the side of the cavity (v, v,) hole to let the neck of the vessel through. 6. All *paratus* being thus ready, you first introduce through o of the tower *(b, b, b, b,)* a few burning coals; and oon them some of the unkindled fuel of the fire; that vity of the tower may, according as it is thought ry, be filled either entirely or only in part. Then l speed you put upon it the iron-cover *(f)*, and strew rder of this on the outside with *sand* or *ashes*, which ress gently with your hands: for if you should t this point, all the fuel contained in the tower would dled, and may endanger setting the house on fire.

shall here annex a few general rules concerning the n of the fire in this furnace: for it is hardly neces-o explain all particulars, since practice will easily hem to such as shall be ever so little acquainted with istry. The fire may be made very strong in the first er, (b, b, b, b, i, i,) when the door of the ash-hole (c), ne funnel (q, q, q, q,) of the chamber is quite open, hen the iron-slider suspended with chains (6. p, p,) ot hinder the fire from passing freely from the tower is cavity. But the closer the funnel is shut, together he door of the ash-hole, the more the violence of the iminishes: and this will be soon effected, if the iron-suspended with chains is let down in part: for the ontained in the tower burns at least as high as the between the lower edge of the iron-slider and the *(d)*. Observe besides, in those operations wherein und hole of the door is stopt with a plug, that when ongest fire is required, this hole must not be kept pen; because the air rushing violently through it, ools the bodies put into the cavity. The operations mentioned may be performed in the second and third er, in, and at the same time, and with the same fire, y are in the first chamber; for the fire penetrates from st cavity into the second, and increases when the (2, 2, 2, 2,) erected on it is opened: but before you do he funnel of the first cavity must be shut as much

as that of the ſecond is opened. By the ſame means, you may hinder the fire, which ſerves for the operations made in the two firſt cavities, from going out through the funnels, and you force it out, on the contrary, through the third cavity and through its funnel (5, 5, 5,); that it may alſo act upon the bodies placed in that cavity. For the more the funnel erected upon the third cavity is open, the more one, or even both funnels of the other two cavities muſt be cloſed: thence it is plain, that you cannot kindle the ſtrongeſt fire in the third cavity, unleſs there be one equally ſtrong in the other two; and that, on the contrary, the heat in the third cavity may be rendered leſs, by cloſing its funnel; though it be violent in the others. The ſame is true of the ſecond cavity, with regard to the firſt. Finally, you cannot make the ſtrongeſt fire under the muffle placed within the upper door *(e)* of the tower, unleſs you have an equal fire in the firſt cavity, which fire may conſequently be increaſed, by ſhutting the door quite againſt the muffle *(e)*, and diminiſhed by opening it; there being mean while an equal heat in the firſt chamber, and in the following ones. The reſt will eaſily be learned by practice."

FIG. 3. A REVERBERATING FURNACE.

a, The aſh-hole door.
b, The fire-place door.
c, *c*, *c*, *c*, Regiſters.
d, The dome or reverberatory.
e, The conical funnel.
f, The retort in the furnace.
g, The receiver.
h, *h*, Iron bars to ſuſtain the retort.

FIG. 4, 5, 6, 7, *and* 8, repreſent a MELTING FURNACE. Theſe figures and the following deſcription of this furnace are copied from *Cramer's Art of Aſſaying Metals*.

The melting furnace is made of iron-plates, the inner ſurfaces of which are covered with lute. The cavity of it may be formed according to an elliptical mould. 1ſt, Make an hollow ellipſis, the focus's 12 inches aſunder, and the ordinate 5 inches long; cut it off in both its focus's, that it may aſſume the figure *(Fig 4.)*. 2dly, Then make in this hollow body, and near its lower aperture, four holes, eight lines in diameter, and directly oppoſite (*c*, *c*,). 3dly, Then faſten two flat iron-rings *(d)*, almoſt one inch and a half broad, at both the upper and the lower inward edge of this oval cavity; and fill the inſide of it with ſmall iron-hooks, jutting out about ſix lines, and three

r inches diſtant from each other. Theſe, together
the rings juſt mentioned, ſerve to faſten the lute.
will the body of the furnace be made: only you muſt
the outſide two iron-handles (*e*, *e*,) to be rivetted on
de of it, that it may be taken hold of and moved.
Then make the cover of the furnace, which may
ned like the part cut off from the ellipſis (See *Fig.* 5,).
is have an opening (*b*) made in it, four inches high,
ches broad at bottom, and four inches at the top;
lapt to this an iron door hung on hinges to ſhut it
and having at the inſide a border faſtened to it,
ing exactly to the circumference of the door, and as
nent inwardly as the thickneſs of the lute to be ap-
o it requires: for the ſame purpoſe, let ſmall iron-
be faſtened to the inſide of the door, which is inter-
by the ſaid border. And leſt this cover ſhould be
within by the force of fire, you muſt cover the
of it over with the ſame lute mentioned before for
ay-oven: therefore it muſt be likewiſe furniſhed with
and iron-hooks to faſten the lute; as was ſaid before,
we ſpoke of the body of this furnace. Beſides this,
uſt faſten two iron-handles (*Fig.* 5. *c*, *c*,) on the outſide
cover. Then a round hole muſt be made in the top
being three inches in diameter, prolonged into a
tube (*d*) almoſt cylindrical, and a few inches high,
which the iron-funnel deſcribed may, in caſe of
ty, be put after the manner mentioned in the ſame
where we ſpoke of the aſſay-oven. 5thly, After this,
ing of both the body and cover of the furnace within
le in the ſame manner above-deſcribed. Moreover,
uſt make for this furnace two moveable bottoms,
ne to receive the aſhes, and admit the air; the other
e for reductions. The firſt is made with an iron-
formed into a hollow cylinder, open at top, and
ſhut at bottom with an orbicular iron-plate, as
baſis, five inches high, and of ſuch a diameter,
t it may receive the inferior orifice of the body of
nace (*Fig.* 4.) the depth of half an inch (*See Fig.* 6.):
re let an iron-ring (*c*), half an inch broad, be
d on the inſide of the ſaid bottom, and at the diſtance
an inch from its upper border, to ſupport the body
furnace put into it. Again, let this bottom have a
door, four inches high, and as many inches broad,
ay be ſhut cloſely with a door hung on hinges, that you
y means of it increaſe or diminiſh the draught of the

 air,

air, and thus govern the fire at pleasure. Then, on th left side of this door, and at about half the height of thi bottom part, let a round hole *(d)* be made, one inch and a half in diameter, to admit the pipe of the bellows when need requires. Next to this, let another bottom part be made of the same matter and figure as the foregoing: let it be likewise of the same diameter, but two inches higher, so that it may be of the height of seven inches. Likewise let it have round it a like iron-ring below its upper border, to support the body of the furnace to be received in it. But let a hole two or three inches broad, and one inch high *(Fig* 7. *c.)*, be cut out just below the ring in the side of this bottom part; then let another round hole be made in the left side of this first hole, fit to admit the pipe of the bellows *(d)*. Further, let another round hole like the foregoing (*e*) be made on the right, and at the distance of one inch from the bottom: then let the whole inside of this bottom part (the part above the ring excepted) be overlaid with lute, and a bed be made at the bottom, of a figure like that represented by the line *(f, g, h,)*. The matter of which this is made is common lute pulverised, passed through a sieve, and mixed with such a quantity of dust of charcoal, sifted in the same manner, so that the mixture being moistened and pressed down, may at least be lightly coherent. Of this matter pressed on the bottom of the bottom part a bed is made, like a segment of a sphere, having in the middle a small cavity somewhat lower, and made extremely smooth, after the manner mentioned before when we spoke of large ash-vessels or tests.

This furnace is chiefly fit for fusions, which may be made in it with and without vessels. When you are to melt with a vessel, put the body of the furnace *(Fig.* 4.) upon the first bottom *(Fig.* 6.), that has a door to it to open on hinges; introduce two iron-bars through the holes of the furnace *(Fig.* 4. *c, c,)*; put upon them the iron-grate, which you are to introduce through the upper mouth of the furnace: then put in the middle of this grate a *brick* or square *tile*, very smooth every where, warmed, and perfectly dry: otherwise, the vessels put upon it, especially the large ones, are easily split by the moist vapors coming out of it in the operations. Let the height and width of this *stone* be a small matter broader and higher than the bottom of the crucible or pot to be set upon it; for if it were less high, the bottom of the vessel could not be sufficiently warmed; and if it were less broad, the vessel might easily fall from it: then

ut upon this *tile* the veſſel containing the matter to be
, and ſurround it immediately with coals on every
which muſt be ranged according to the method pre-
l before, in our deſcription of the aſſay-furnace:
ou govern the fire, by opening and ſhutting the door
aſh-hole (*Fig.* 6 *b*): you excite it by putting the
(*Fig.* 5.) upon the body of the furnace; and if,
, you put a funnel upon the cylindrical mouth (*d*)
cover, the melting fire becomes ſtill more violent:
you moreover introduce the bellows through the
f the bottom part (*Fig.* 6. *d*); and the joint of the
e with the bottom part, and the door of the aſh-hole,
it can be ſhut very cloſe, being exactly ſtopt with
ute [*or Windſor loam*], the fire thus excited by the
f the bellows is carried to the higheſt degree, and far
es that which may be made in a Smith's forge. Another
age of this method is, that the veſſels are not ſo eaſily
, becauſe the blowing of the bellows cannot affect
immediately, and becauſe a fire perfectly equal is ex-
on every ſide. One may eaſily examine with this
tus, how *ſtones* are affected by the violence of the
ly. Now, if you have a mind to perform any opera-
ithout a veſſel, and with a naked fire; for inſtance,
t and reduce the *calxes* or *ſcorias of copper*, *tin*, *lead*,
n, or the ores of theſe metals; the body of the furnace
e put upon the other pedeſtal, having a bed in it
.). However, you muſt, before this, open with a
the oblong hole (*c*), and the round one (*d*) of this
part, which are ſtopped with the lute ſticking to
ſide: then you apply at the round hole (*d*) on the
le of the bellows, in ſuch manner that the nozzle of
ng directed obliquely downwards, may blow ſtrongly
the bed (*f*, *g*, *h*,): by this means, all the aſhes that
to the bed are blown away, and the ſtrength of the
termined to ſuch a degree, that all the melted bodies
all into the ſaid bed remain in their ſtate of fuſion;
ere it otherwiſe, the melted bodies would immedi-
wax cold, and adhere in grains to the bed, whereas
ught to have melted into one *regulus*. The oblong
n the fore-part of this bottom-part (*c*) ſerves to
er, by means of a poker, whether the matter in the
e melted or not: it ſerves likewiſe to take away
h it whatever might ſtop the bellows, and in ſome
o take away the *ſcoria*: then you put firſt coals into
urnace one ſpan high, and blow them well with the

 bellows,

bellows, to make them burn, that the bed may be very before the matter to be melted is put into it; for if t not previously done, the melted mass seldom runs i *regulus*, but remains dispersed among the *scorias*, w soon grow hard. The bed being well heated, and coals added to the fire, put into it such quantity o matter to be melted as cannot hinder the fire from b carried to the requisite degree; which cannot be d mined otherwise than by experience: again, put coals, and upon them another quantity of the matter melted; they may be, like *strata*, one upon another: if the mass, once melted, could not long sustain the stre of the fire, or if you had a mind to melt a greater qua of matter than what can be contained in the bed, you open the round lower hole (*Fig.* 7. *e.*), that you make a channel passing from that hole through the and reaching to the small cavity at the bottom of the (*g*): to this hole, at the outside, apply an earthen dish the bed within, or any other proper recipient, surrou with burning coals, into which the matter melted run from the bed through the hole (*Fig.* 7. *e.*), may be colle as is represented by *Fig.* 8.

FIG. 9. A transverse section of a FURNACE in w SULPHUR is obtained *by distillation* from pyrites. In furnace are placed ten or twelve tubes, one of whic represented in this section (7), lying across the w breadth of the furnace. These tubes are open at both e At the larger end the mineral, from which the sul is to be distilled, is to be introduced; and then the ope is to be closed with an earthen stopper. The smaller opens into a cast-iron receiver (8), which receives sulphur that is distilled or eliquated. To prevent crude mineral from passing into the receiver, a star- piece of baked earth is placed in the neck or smaller of the tube, along with the sulphur. Each furnace tains ten or twelve such tubes. The length of the w furnace is therefore evidently much greater than its brea The tubes are about four feet long, somewhat of a co form, six or eight inches wide at their larger end, and quarters of an inch at their smaller end.

1. The walls of the long sides of the furnace.
2. The ash-hole.
3. The grate made of bricks.
4. The fire-place.

5.

EXPLANATION OF PLATE II.

. The paſſage for the flame to the upper part of the fur-nace.
. The two walls of the long ſides of the furnace which ſupport the tubes.
. A tube placed acroſs the furnace.
. A ſquare caſt-iron receiver.
. Two holes in the roof of the furnace through which the ſmoke eſcapes. There are generally ten or twelve ſuch holes in different parts of the roof, ſome of which are occaſionally cloſed. *See a further deſcription of this furnace, and of the operation of extracting ſulphur, at the article* SMELTING *of* ORES.

G. 10. This figure repreſents a tranſverſe ſection of a NACE *for* PURIFYING SULPHUR *by* DISTILLATION. SMELTING *of* ORES.

. The foundation of the wall ſunk under ground.
. The ſide-wall.
. The back-wall.
. The aſh-hole.
. The grate.
. The fire-place.
. Two holes through which the ſmoke eſcapes.
. The inner chamber of the furnace.
. An iron cucurbit or pot.
. A neck made of earthen-ware.
. The veſſel called the fore-runner.
. A receiver.
. A banquette or ſtep raiſed to ſupport the fore-runner. In this furnace, which is of an oblong ſhape, generally five or ſix ſuch ſetts of diſtilling veſſels are placed on each ſide.

G. 11. Repreſents a *quantity of ore piled up to be roaſted.*

. Two ſides or faces of the pile. All the ſides of it are covered with ſmall ore.
. The upper part of the pile, where holes or cavities are ſeen in which the ſulphur of the ore is collected.
3. An opening where part of the pile has fallen down, and in which the ſulphur is ſeen dropping down.
4. A plank to keep off the wind. *See* SMELTING *of* ORES.

IG. 12. *A Section of the above Pile.*

1. The wood to make the fire.
2. Some charcoal for the kindling of the fire.
3. A channel formed by a wooden tube or pipe.

4. The

4. The large lumps of ore.
5. Small ore.
6. Finer ore, or duſt of ore.
7. The ſubſtance called *vitriol*, that is, a half
ore powdered.

FIG. 13. Repreſents a longitudinal ſection of th
NACE *at* RAMMELSBERG. *See a deſcription of this*
at the article SMELTING *of* ORES *of* SILVER.

1. Foundation of the maſonry in the ground.
2. A part of the back-wall.
3. The tuyere.
4. Channels to carry off moiſture.
5. The covering ſtone of theſe channels.
6. A bed of ſcoria.
7. The caſe or caſſe made of bricks.
8. A bed of clay.
9. A bed of ſifted ore and ſubſtance called vitrio
10. The charcoal which is thrown into the caſſe p
to the filling of the furnace with ore and fuel
11. A mixture of fat earth and charcoal powde
which the furnace is prepared or lined.
12. The hearth, with the trace.
13. The ſeat of the zinc.
14. The chemiſe.
15. The wall of one ſide of the furnace.
16. The middle wall of the furnace.

FIG. 14. Repreſents a longitudinal ſection of a R
BERATORY FURNACE uſed in the *ſmelting of ores.*
deſcription of this furnace at the article SMELTING *of* C
COPPER.

1. The maſonry.
2. The aſh-hole.
3. A channel for the evaporation of the moiſture.
4. The grate.
5. The fire-place.
6. The inner part of the furnace.
7. A baſon formed of ſand.
8. The cavity where the melted metal is.
9. A hole through which the ſcoria is to be remo
10. The paſſage for the flame and ſmoke, or th
part of the chimney, which is to be carried
height of about thirty feet.
11. A hole in the roof, through which the ore is
into the furnace. This furnace is eighte

long, twelve feet broad, and nine feet and a half high.

IG. 15. Represents the upper plan of the FURNACE, of ch FIG. 14. is a section.

1. The outer wall.
2. The draught-hole communicating with the ash-hole.
3. The door through which fossil coal is thrown into the fire-place.
4. The place where an opening is made to let the melted metal flow out of the furnace.
5. An opening through which the scoria is drawn off.
6. The bason made of sand where the metal lies.
7. The fire-place with an iron-grate.
8. A small wall between the fire-place and the area or bason, over which the flame passes.

IG. 16. Represents the plan of a REFINING FURNACE refining silver or copper. *See* REFINING *and* SMELTING ORES *of* SILVER.

1. The pillars and walls of the furnace.
2. The bason of bricks, about eight feet in diameter.
3. The base of the vault of the furnace.
4. The great flame-hole, through which the metal to be refined is introduced.
5. Two holes for the bellows.
6. The hole through which the litharge runs off.
7. The grate on which the fire is made.
8. The door of the fire-place through which the wood and faggots used as fuel are introduced.
9. A bason for the reception of the refined copper, when that metal is refined in this kind of furnace.
10. A passage which is to be occasionally opened to let the copper flow out.

FIG. 17. Represents a *longitudinal section* of the refining nace, of which FIG. 16. is a plan.

1. The masonry of the pillars and walls surrounding the furnace.
2. The channels for carrying off the moisture.
3. Other small channels which join in the middle of the bason.
4. The bason made of bricks.
5. A bed of ashes.
6. The hollow or bason in which the metal is melted and refined.
7. The great flame-hole.

8. The

8. The two openings for the entry of the tuyeres
bellows.
9. The vault or dome of the furnace.
10. The fire-place.
11. The grate.
12. The draught-hole.
13. A hole in the vault, which, being opened, fer
cool the furnace.

FIG. 18. Reprefents a fection of an AIR MEL
FURNACE.

1. The mafonry.
2. The grate.
3. The afh-hole.
4. The afh-hole door.
5. The fire-place and fuel.
6. A crucible or pot containing the metal to be r
ftanding upon a brick fupport, and covered
tile.
7. A horizontal flue or paffage through which th
paffes to the chimney (8). In this horizont
a brick door opens laterally oppofite to the tef
By this means the fame furnace ferves both
melting furnace for melting metals in cru
and alfo for the operation of tefting or cupel
8. The chimney.
9. The mouth of the furnace through which
thrown. This mouth is covered with a ftone
iron-plate.
10. A teft furrounded by fand. The flame of t
ftrikes upon the metal contained in the cavity
teft.
11. An aperture through which the flame paffes in
horizontal flue. The area of this aperture i
fourteen to twenty-two fquare inches.

The dimenfions of this furnace may be fuited
quantities of metal to be melted. General
area of the plan of the fire-place is from 64
fquare inches, that is, the length of each fide
area is from 8 to 12 inches.

This complex furnace is ufeful to refiners of go
filver: but where the tefting part of the furnac
wanted, as in furnaces for melting brafs or fte
horizontal flue (7) need not have any lateral c
or door. The length alfo of this flue may be

ed, and its width made equal only to that of the aperture (11).

Fig. 19. This figure reprefents a vertical tranfverfe fection of a Reverberatory Furnace invented by Schlutter for the procefs called *eliquation*, by which filver is feparated from copper. *See the article* Eliquation.

1. The mafonry furrounding the furnace, excepting the front (9).
2. Two walls inclined to each other, covered with the two iron plates (7, 7,) that fupport the metal (8) to be eliquated.
3. The way through which the lead and filver eliquated from the metal (8) flows towards a bafon made for its reception without the furnace.
4. The infide of the furnace.
5. The afh-hole.
6. The grate and fire-place, from which the flame paffes towards the plates of metal (8), and efcapes at a chimney in the end of the furnace moft remote from the door of the fire-place.
7. Two plates of iron.
8. A cylindrical piece of metal compofed of the copper containing filver, and of a fufficient quantity of lead to caufe the eliquation. The filver and lead thus eliquated from the copper, fall down into the cavity (3), and flow into a bafon on the outfide of the furnace. In this furnace ten or twelve fuch cakes or cylindrical pieces of metal are placed parallel to each other.
9. The front of the furnace, through which the pieces of metal are introduced. This front is clofed with an iron door lined with clay, the length of which is equal to the length of the internal part of the furnace. This door may be raifed by means of a chain and pulley, when the pieces of metal are to be introduced.

Fig. 20. Reprefents a vertical fection of a Furnace *for* Smelting *of* Ores *of* Iron.

a, a, b, b, The height of the furnace above the level of the ground.

b, b, c, c, The part of the furnace below the level of the ground.

d, d, Shew the height where the great mafs of mafonry terminates, and the fmaller mafs and thinner walls called *battles* begin.

d, *a*, *a*, *d*, One of these walls called *battles*.

e, The mouth or upper opening of the furnace.

f, *f*, A platform.

g, *g*, Sections of the smaller mass of masonry.

i, *i*, The beginning of the etalage. The space *i*, *i*, *e*, is sometimes called the *charge*.

k, *k*, The end of the etalage, and the beginning of the work.

i, *k*, 1, and *i*, *k*, 2, Are sections of the etalage.

e, The bottom of the work.

m, The place where the melted metal and scoria flow out of the furnace. The scoria flows over the dame (*n*), and the metal flows at the bottom of the dame, and on one side of it, through passages made occasionally in the bank of sand and clay, with which this lower part of the front of the furnace is closed.

n, The dame.

o, A workman opening a passage for the scoria over the dame, by means of a bar of iron.

p, *b*, A section of the arched space or embrasure, in the front of the furnace, under which workmen stand.

Q. The vault under the furnace.

R, R, Beams of wood to strengthen the walls of the furnace.

X, A workman throwing fuel and ore into the furnace.

FIG. 21. Represents a *plan of the above furnace* taken at a level with the tuyere.

k, The work.

m, *s*, The front of the furnace.

n, *n*, The bellows.

o, The tuyere.

p, *q*, The outer walls of the furnace.

r, *r*, Two iron bars or pokers placed upon the dame (*s*).

m, The opening through which the metal flows.

m, *t*, The channel, and moulds made in a bed of sand, for the reception of the iron, when it flows out of the furnace.

x, *x*, The inner walls of the furnace.

FIG. 22. Represents a vertical section of a reverberatory furnace, used for the obtaining of ZINC from its ores. The construction of this furnace resembles nearly that commonly used for making of glass. It is a reverberatory vaulted furnace, the plan of which is circular. The hearth of this furnace is supported by arched pillars. On this hearth, six large pots, each of which is about four feet high,

high, and contains some hundreds of pounds of ore of zinc, and of charcoal, or other inflammable matter, are placed in a circular row. Two of these pots (2, 2,) are represented in this section. A circular hole (4) is left in the hearth for the passage of the flame from the fire-place into the reverberatory, from which it escapes at a hole in the arch (9). In the head of each of these pots there is a hole for the introduction of the ore, which hole is stopped, during the operation, with a stopple of baked earth (1, 1,); and also there is a hole in the bottom, corresponding with a hole on that part of the hearth on which the pot is placed. Through each of these latter holes is inserted an iron tube (3, 3,), which is closely luted to the contiguous parts of the pot and hearth of the furnace. The pots are to be filled with the mixture of ore and coal, in the following manner: The stopple (1) of the mouth of a pot is to be removed, and into this mouth, one end of an iron tube or funnel is to be inserted, through a hole (8) in the vault immediately above the pot, while the other end of the tube or funnel remains without the furnace. Through this tube the mixture of ore and coal is introduced into the pot; then the tube is removed, the stopple is fitted and luted with fresh clay to the mouth of the pot, and the hole in the vault (8) is to be covered with a lid.

When the ore thus introduced is sufficiently heated, the zinc is revived or reduced by the inflammable matter mixed with it, rises in the state of vapor, which finding no other vent, passes down the tube (3). The lower end of this tube (3) being in contact with the external air is sufficiently cold to condense this vapor of zinc, and the zinc accordingly flows out of the lower end of the tube in the state of a melted metal, and falls or drops into a vessel (7) containing water, where it becomes solid. Thus zinc is obtained from its ores by the kind of distillation called *per descensum*. When the distillation is finished, which is generally in three or four days, according to the heat applied, the nature of the ore, and other circumstances, the tube (3) is removed, the residuum is thrust out of the hole in the bottom of the pot by means of an iron bar or poker introduced through the opening of the vault (8) and the upper mouth of the pot. When the pot is emptied of the exhausted ore, the tube (3) is to be replaced, fresh ore and coal are to be introduced in the manner above-mentioned, and the operation is to be repeated,

peated, without cooling the furnace or removing the vessels.

This section is not taken from an exact mensuration, and therefore the proportions of the several parts are not accurately shewn. Nevertheless, as this method of obtaining zinc has not before been published, the present figure may help to explain this singular process.

ADDITIONS

TO THE

ICTIONARY

OF

CHEMISTRY.

BY

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C O N T E N T S.

ition to the Article VITRIOLIC ACID, *of the former Edition.*

CID (VITRIOLIC). When vitriolic acid is well concentrated, it is capable of congealing by a degree of cold expreffed by r 14° of *Reamur*'s thermometer. For the knowledge of this rty we are indebted to the zeal which the *Duke d'Ayen* has for iences. He has lately communicated to the academy a fet of iments and obfervations, no lefs important than curious, for he availed himfelf of the extraordinary cold at the end of *ary*, 1776. He expofed to this cold different matters, and, among vitriolic acid in different degrees of concentration. Some very ntrated vitriolic acid, expofed in a window, in a porcelain cup, g the night of the 27th of *January*, was entirely frozen in 7 hours. At the fame time were expofed to the fame cold, and in me manner, mixtures confifting of one part of the fame acid, to f which two parts, and to another four parts of water had been l, without any appearance of congelation at the end of 30 hours. e *Duke d'Ayen* relates in a letter which accompanies his me- that having diluted one part of the acid with eight parts of , this mixture could not be frozen with the fame degree of cold h had congealed the pure concentrated acid. But what muft r the moft extraordinary to perfons to whom the phenomena emiftry are not familar, is, that this fame concentrated vitriolic which was entirely frozen in eight hours, thawed fpontane- in the fpace of thirty hours, although the cold rather encreaf- an diminifhed towards the latter part of the time. The caufe is fingular effect did not efcape the *Duke d'Ayen*, who was fen- that as the concentrated vitriolic acid, when expofed to air, ts moifture; and as a degree of heat is always excited by this mixing with water, and alfo, as he had difcovered that this acid ndered lefs capable of freezing by being diluted with water, caufes muft concur to deftroy the congelation.

though the mixture of even a confiderable quantity of water vitriolic acid obftructs the congelation of this acid, (water being ole of freezing with a much lefs degree of cold than the pure entrated acid) there muft be fome limit of dilution, at which the tity of water will be fo great as to determine the mixture to e at even a lefs cold than the concentrated acid does; and ac- ngly the *Duke d'Ayen* found from an experiment, that fome olic acid which did not freeze by a cold of ten or twelve de- , when its fpecific gravity was to that of diftilled water, as o 96, began to freeze at the fame degree of cold, when the was fo much diluted, that its fpecific gravity became to that of r, as 104¼, or even as 103¼ to 96.

ARSENIC. Mr. *Navier*, Phyſician at Chalons, has lately publiſhed his reſearches into the remedies againſt metallic poiſons, and eſpecially arſenic. Being convinced from experience, that liver of ſulphur, martial liver of ſulphur, and alſo other ſolutions of iron in acids or in alkalis, can be readily decompoſed by arſenic, even in the humid way; and that in theſe decompoſitions the arſenic unites with the ſulphur or with the iron, he propoſes to employ theſe ſubſtances, and even ink, when the others are not at hand, as antidotes to arſenic. Theſe ideas muſt be approved by every perſon who underſtands chemiſtry, for ſince experience proves that arſenic unites in the humid way to the ſulphur of the hepar, and to the iron of the martial ſolutions, it follows, that it ought to loſe more or leſs of its cauſticity, in proportion to the intimacy of union which it contracts with theſe matters.

BLACK-LEAD; Called alſo, *Molybdena*, *Plumbago*. This matter, which is found in ſome mines, was not known till lately, but by the uſe that is made of it. It is commonly employed as a black crayon or pencil, and as a covering to the ſurface of utenſils made of iron, in order to preſerve them from ruſt, and to give them a good appearance. It is alſo mixed in a large proportion with clay, to form a compoſition for making the crucibles, which are called *Crucibles of Paſſau*, or *Black-lead crucibles*, and which are capable of ſuſtaining violent heat. As no metal can be obtained from it, ſo as to produce profit in the ſmelting of it, metallurgiſts had entirely neglected to examine it.

Mr. *Pott* is the firſt chemiſt who has given any attention to this matter. He has publiſhed a diſſertation on it. Although Mr. *Pott* is more engaged in this diſſertation in diſcuſſing the ſentiments of authors concerning it, and in ſhewing its uſes, than in making an accurate analyſis of it, the reſult, however, of the few experiments which he made is, that it contains no lead nor any other metal but iron. It is compoſed, according to this chemiſt, of a very refractory talky matter, and of a little vitriolic acid. The iron which black-lead contains, was partly indicated in Mr. *Pott*'s experiments, by the action of acids, which diſſolved ſome of the contained iron, but not the whole of it, and by ſublimation with ſal ammoniac, by which martial flowers were produced. He obſerved alſo that the ſmoothneſs or unctuoſity of black-lead, is not deſtroyed by acids, nor even by great heat, which ſeems to ſhew that this property proceeds rather from the ſcaly and ſmooth form of its particles, than from any matter which can be called properly greaſy, although we ſhall hereafter ſhew that bleak-lead contains a good deal of phlogiſton.

We are indebted for the moſt extenſive and moſt ſatisfactory reſearches on this ſubſtance to M. *de L.* who has lately communicated them to the academy of ſciences in a very good memoir on this ſubject, and he has been pleaſed to give me leave to communicate them before the publication of that memoir.

Black

Black-lead being exposed to a very violent fire in a crucible during two hours, was not observed by M. *de L.* to be sensibly diminished in weight: But having put some powder of black-lead on the bottom of a muffle heated white, he observed upon its surface an undulating motion, which continued till all the mica was decomposed or evaporated, and after it had been exposed to the fire while this undulation lasted, he found that nothing remained but a reddish-brown powder, which was attracted by a magnet, the certain indication that iron is contained in this mineral. But the most remarkable part of this experiment was the loss of weight which was sustained by torrefying this matter, in other respects so refractory; which loss Mess. *Pott* and *Quist* had before observed, and which was found by *M. de Lisle* to be so considerable, that of the soft kind of black-lead ninety parts out of a hundred were lost, and of the hard kind eighty-eight parts out of a hundred. So considerable a loss, which does only take place in circumstances necessary to combustion, seems to indicate the existence of a much greater quantity of combustible matter in black-lead than could have been suspected.

The residuums of these torrefactions yielded, by reduction, iron, in the proportion of two pounds four ounces of this metal to a hundred weight of soft black-lead, and of three pounds four ounces of iron to a hundred weight of the hard kind of this mineral. The iron proceeding from the soft kind was strongly attracted by a magnet, but the iron of the harder kind was not very sensible to the action of the magnet. This difference gives occasion to suspect, that notwithstanding the long torrefaction, the iron of the hard black-lead was not perfectly freed from sulphur, for nothing but sulphur can prevent iron from being attracted by the magnet.

I have remarked at the end of the article on *Ores*, that if we would know them very well, we must not be contented, as we have hitherto generally been, with submitting them to the action of fire in crucibles, but that it was very essential to collect their volatile parts in close vessels, by distilling them with and without intermediate substances. Several chemists, particularly M. *Sage*, have begun to follow this good method, which has already procured some important knowledge.

We find a new instance of the benefit of using this method in the memoir of *M. de L.* He exposed black-lead singly to the action of fire in close vessels, and distilled it in a retort which he kept red-hot during several hours, having previously put into the receiver some liquid fixed alkali, as M. *Sage* has practised in several of his analyses, and although he observed that this mineral did not lose any sensible weight by the distillation, yet the alkali was found to have formed cubic crystals; which circumstance induced him to

believe that some volatile acid had escaped from the black-lead, which acid uniting with the alkali, had occasioned it to crystallize.

If the nature of salts could be determined by the form of the crystals, and if sea-salt only assumed in its crystallization the cubical shape, this experiment would prove the existence of the marine acid in black-lead: But the form of crystals is a deceitful mark, and not sufficiently certain to ascertain the nature of a salt without other concurrent proofs. Accordingly *M. de L.* not depending on this circumstance, made other trials. He found that this salt precipitated silver from its solution in nitrous acid. But the compleat reduction of this precipitate by the sole action of fire, proved that the acid in question was not the marine, since this latter acid forms a luna cornea, which not only cannot be reduced without addition, and merely by heat, but cannot be reduced without some difficulty even by addition of intermediate substances. *M. de L.* suspects that this acid of black-lead is the same as that of the spathose ores. Most of these ores, being treated by the same process, exhibit the same phenomenon. But it is now known that this acid is the gas, known by the name of *fixed air*, or *mephytic gas*, which has no property in common with marine acid.

As it is very possible, that if we proceed to examine minerals more accurately than has been done, we shall find several which yield volatile substances, and even gases incapable of being fixed by alkalies, such as *inflammable gas*, it follows, that the method of putting liquid fixed alkali into receivers is defective, and may lead to error, and that it is necessary to employ for this purpose the pneumato-chemical apparatuses, which are adapted to the purpose of receiving and measuring the quantity of the gas expelled.

M. *de L.* exposed black-lead to the action of several intermediate and dissolving substances. He distilled two parts of vitriolic acid with one part of black-lead, and he observed, that the receiver was filled with white vapours, and a volatile sulphureous acid, which continued to smoke even some days afterwards, when the bottle containing it was uncorked. This operation being repeated four times successively, and the same acid being cohobated always upon the same black-lead, the acid at length became of a beautiful green colour, and by evaporation yielded first an ochery precipitate, as solutions of martial vitriol do, then a foliated and shining selenites, and lastly crystals of alum.

The most remarkable circumstance is, that notwithstanding so many cohobations of vitriolic acid, the remaining black-lead was still black and unctuous.

Nitre mixed in equal parts with this mineral, and exposed to fire in an open vessel, detonated; but the residuum nevertheless retained its black colour. When the same mixture was distilled in a retort, vapours of nitrous acid were produced; but when the bottom

bottom of the retort began to be red-hot, a detonation happened, which burst the vessels.

Lastly a mixture of equal parts of black-lead, and sal ammoniac, being sublimed, yielded flowers of sal ammoniac, evidently martial, of a lively yellow colour, the solution of which formed an ink when mixed with an infusion of galls. But when this sublimation was repeated upon the same black-lead, the colour of the flowers became fainter each time, and at length they were white, as M. *Pott* also had observed. But M. *de L.* mentions two circumstances which M. *Pott* has not observed. The first is, that the black-lead from which the sal ammoniac rose white, was not altered in colour nor in texture by the operation: and the second is, that the bottom of the glass vessel which had been used in these operations, had acquired very evident rainbow colours.

It seems to be well proved from the experiments of M. *Pott*, and still better by those of M. *de L.* that the greatest part or basis of black-lead is a micaceous talky matter, the earth of which being of an argillaceous nature, forms alum, with vitriolic acid, according to M. *Sage*'s observation; that this talky matter is so intimately combined with a certain quantity of ferruginous and phlogistic matters, which perhaps are nothing else than iron itself, as M. *de L.* judiciously observes, that neither combustion, nor the most powerful agents can deprive it entirely of these matters; and lastly, that in this mineral a volatile substance also exists, which seems to be acid, but of which the nature and quantity is not yet perfectly ascertained, and requires new researches of the kind which I have mentioned above.

BLOOD.

THE analysis of blood was but little advanced at the time of the publication of the first edition of the Dictionary of Chemistry, and I therefore confined myself to wishes that it might be further prosecuted. These wishes have been since fulfilled beyond my expectations by M. *Rouelle* and M. *Bucquet*. The former has published his experiments in the *Journal de Medicine for* 1773 *and* 1776, and the latter in a memoir presented to the Academy of Sciences, not yet printed.

Before the researches of M. *Rouelle*, some authors, particularly *Haller* and *De Haen*, had observed that saline matters existed in the blood. *De Haen* particularly had deduced the presence of an alkali from the observation that water in which coagulated blood was washed was alkaline, and that dried blood effervesced with acids. M. *Rouelle* undertook to determine the kind and the proportion of this alkali, and whether it was in a combined or disengaged state.

Having obferved that not only the ferum of the blood of men and quadrupeds, but alfo the waters collected in different kinds of dropfies, have the property of being coagulated by moft acids, by heat of boiling water, as the white of an egg is, of being mifcible with water, of acquiring a confiftence, and clarifying liquors like the other animal lymphatic fluids, and of changing the colour of fyrup of violets to green as fenfibly as water in which an alkali had been diffolved; and having convinced himfelf from experiment, that the water diftilled from the blood in a water-bath does not, while recent, in any degree alter the colour of fyrup of violets, has thence juftly concluded, that the property of making the fyrup green is not owing to the alkaline quality of the ferum of blood, nor to a volatile alkali contained therein, as fome authors had thought, but to a difengaged fixed alkali. His proofs are, that after a diftillation of blood in a water-bath, the dry brittle matter, more or lefs coloured, and refembling glue, (from which however it is different in this refpect, that it is not eafily foluble in water) contains really a fixed marine alkali, uncombined, which cryftallizes in form of a faline effervefcence, and which may be collected from the furface of this matter after it has been kept in a glafs jar, covered only with paper, during a year, or a lefs fpace of time, while this matter foftens and ceafes to be brittle, by means of the moifture which it receives from the air.

To this proof, fufficiently convincing of itfelf, M. *Rouelle* adds feveral experiments. "If (fays he) five or fix pounds of ferum of "blood, or of the water of dropfies, be diluted in twice as much "diftilled water, to which, from fix gros to an ounce of common "vitriolic acid has been previoufly added, if thefe be well mixed "together, and the mixture firft dried in a water-bath, then re-"peatedly wafhed with boiling water, and if the lotions or water "thus employed, (which are acidulous) be faturated with chalk, "fo that the fuperabundant vitriolic acid may be engaged, the li-"quor, after filtration and evaporation in a water-bath, will yield "a true Glauber's falt." To prevent the objection that might be made from a fuppofition that the vitriolic acid might unite with the marine alkali, even if it were in a combined ftate in the ferum, M. *Rouelle* made an experiment in which he fubftituted diftilled vinegar in place of vitriolic acid, and he obtained fine cryftals of an acetous falt with bafis of marine alkali.

The remarkable exiftence of a difengaged marine alkali in the ferum of blood, and other analogous liquors, is not the only difcovery that has been lately made. The prefence of iron in this liquor is another no lefs important difcovery. This metal has long ago been obferved in vegetable afhes. Some philofophers have confidered it as the caufe of the colour of flowers. Its exiftence has even been fufpected in animals, and the red colour of

blood,

blood has been attributed to it. But the first person who made a continued research into this subject is M. *Menghini*, who has proved that not only the blood contains much iron, especially in its red part, but also that martial preparations taken internally, pass in great measure into the blood, in which it produces, and by the analysis of which it may be again traced. The detail of these researches may be found in the second volume of the *Bolognian Memoirs*. To the experiments of M. *Menghini*, which are very satisfactory, M. *Rouelle* has added still more precision, and has published further observations on the saline matter contained in the blood, as may be seen in the *Journal de Medicine, July*, 1776. According to this able chemist, "the blood of healthy men being dried, burnt "and calcined to ashes, contains fixed mineral alkali; some sea-"salt, a small quantity of febrifugal salt, an animal or calcareous "earth, some iron, and lastly coal. The quantities of the fixed "alkali, and of the neutral salts, were found to be in the propor-"tion of 28 or 29 parts of the fixed alkail, to 16 or 17 parts of "the neutral salts. When the lotions or lixivia of the ashes of "blood are evaporated at different times, sea-salt is first obtained, "then febrifugal salt, and lastly fixed alkali.

"The ashes which remain after these lotions, are composed of a "little animal earth, of coal, and of a considerable quantity of "iron. The animal earth is nearly one-tenth of the whole; and "the quantity of coal is not very considerable, but varies accord-"ing to the degree of calcination.

"When these ashes are treated with pure marine acid, the earth "may be separated from the iron, as the acid unites with the earth "in preference to the metal. The iron then remains mixed with "a little coal, which is not readily separated from it.

"The iron obtained in this experiment is of a fine colour of "martial crocus, although it is attractable by a magnet, and if any "portion should not be attractable, this quality may be given to it "by soaking it in oil of olives, and making it slightly red-hot in a "retort or covered and luted crucible. The iron thus obtained "from blood, is soluble in all acids, and presents the same pheno-"mena as filings of iron dissolved in acids. Thus when vitriolic "and marine acids are employed, the vapours are equally inflam-"mable, and when vitriolic acid is used, a true martial vitriol is "obtained."

M. *Rouelle* has subjected to the same experiments the blood of several quadrupeds, with the same result, but with different quantities and proportions, not only among the different species of animals but also among different individuals of the same species, which differences must proceed from the nourishment or state of health which each animal happened to possess. The saline and ferruginous sub-

ſtances above-mentioned, although they appear to be contained habitually in blood, are nevertheleſs in ſome meaſure foreign to it, and ought not to be conſidered among the eſſential conſtituent parts of this fluid, which conſiſts almoſt entirely of a coagulable, lymphatic, animal matter. In a little time after it has been drawn from the veſſels of a healthy animal, it becomes, by reſt and cold, coagulated, and has a gelatinous appearance. But in time a yellowiſh liquor ſeparates from this coagulum, which appears to be the moſt watery part of the blood and is called *Serum*. This liquor readily mixes with water, and when it is dried in a water-bath, as M. *Rouelle* has done, it aſſumes the appearance and properties of an animal jelly or glue, with this difference nevertheleſs, that it is more difficultly rediſſolved in water than the pure glues, and that it is capable of being coagulated by the heat of boiling water, as the white of eggs and other lymphatic animal liquors are, ſo that it appears at once to partake of the nature of the gelatinous and of the lymphatic part of animals.

After the ſerum is thus ſpontaneouſly ſeparated from the coagulum, this latter ſubſtance may be further ſeparated into two very diſtinct parts by merely waſhing it repeatedly with water. The water carries off with it the red part which is very ſoluble; and the reſiduum, which is entirely white, is a concrete matter, inſoluble in water, and ſomewhat elaſtic. This matter is called the *fibrous part of the blood.* Of all the ſubſtances which circulate in animal bodies in a liquid ſtate, this appears the moſt diſpoſed to become ſolid, ſince it coagulates even in the cold, and in ſuch a manner that it cannot be any more diſſolved in water, ſo that it may be conſidered as more concreſcible than pure animal lymph.

M. *Bucquet* has principally examined theſe three parts of blood. According to this excellent chemiſt, the coagulation of the ſerous or lymphatic part of the blood is not cauſed by deſiccation or by the loſs of its watery part; but is ſolely the effect of heat.

The water obtained from it by diſtillation in a water-bath, as well as that obtained from other animal matters, although at firſt it be inſipid, and does not occaſion any alteration on ſyrup of violets, is not however pure; for it contains ſome animal matters. The proof of this is that at the end of a certain time, this diſtilled water ſhews ſigns of putridity, of a diſengaged volatile alkali, and renders ſyrup of violets green. M. *Rouelle* has alſo made the ſame obſervation. This ſerum being dried in a water-bath and diſtilled in a retort, yields, as ſoon as it is hot, ſome volatile alkaline ſpirit, a large quantity of ſolid volatile alkali, ſome fetid oil, the greateſt part of which is heavy and falls to the bottom of the alkaline ſpirit. The coal remaining in the retort is very light and ſpongy, and fills entirely

entirely the cavity of the vessel. It contains much sea-salt, and fixed marine alkali, which may be separated by washing with water.

This coal thus lixivated is not easily reduced to ashes. For this purpose it must be kept several hours under a muffle, by which means it becomes a grey ash, like that of vegetables. This ash when it is produced from a serum perfectly free from any mixture with the red part of the blood, contains but infinitely little iron.

This animal liquor mixes with cold water in all its proportions, and if it be thrown into boiling water, one part of it coagulates and another part unites with the water, but is not completely dissolved; for the water becomes and remains milky and cannot be cleared by several filtrations through paper. When it is made to boil, it swells and froths; a pellicle is formed on its surface, like that on milk, and the addition of acids or of spirit of wine coagulates the particles which render the liquor turbid.

The serum of blood is extremely disposed to become putrid; for M. *Bucquet* having exposed some to air, it became putrid in so little time, that he could not determine whether it previously became acid.

When weak acids are mixed with serum, it is thereby coagulated; and when the remaining part of the liquor is separated by filtration, neutral salts may be obtained by evaporation, which salts are formed of the acid employed in uniting with the marine alkali of the serum. The coagulated matter remaining upon the filter, being repeatedly washed, dryed and distilled in a naked fire, yields the same products as the same lymphatic serum which had not been mixed with acids. The coal remaining in the retort contains much marine alkali. It is proved by these experiments, that, if a part of this alkali exists in this liquor in a pure and disengaged state, there is also another part which appears to be combined, and which does not unite to these acids, and which cannot be carried off by the plentiful washing.

The concentrated nitrous acid dissolves the serum after coagulating it. This solution is accompanied with much effervescence, and the dissolved matter may be precipitated by addition of water.

Alkalis do not coagulate the lymphatic serous part of the blood; and the caustic volatile alkali even dissolves it after it has been coagulated by other means. The compound which results from this solution by caustic volatile alkali cannot be decomposed but by the action of an acid.

The neutral salts with alkaline or earthy bases do not occasion any alteration in the serum. But almost all the metallic salts form with it a considerable precipitate.

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We have already ſaid, that the ſerous part of the blood, even that part which can unite with water, is coagulable by ſpirit of wine. And it is well worth notice, that the ſerum thus coagulated by ſpirit of wine may be re-diſſolved in water, but that the coagulum by means of acids cannot be thus diſſolved.

The fibrous part of the blood, that is to ſay, that which forms the coagulum ſpontaneouſly by reſt and cold, after it has been deprived of all the red particles by waſhing in water, yields by diſtillation in a water-bath nothing but an inſipid phlegm, which at firſt is not alkaline, but which becomes alkaline when it has been kept ſome time. M. *Bucquet* obſerves that a very ſmall degree of heat hardens remarkably this fibrous part of the blood, even before it loſes its moiſture. It acquires at the ſame time a dirty grey colour, and ſhrinks as parchment does when expoſed to the ſame heat. This part of blood, being dried and diſtilled in a retort, yields nearly the ſame products as the ſerum does. But the coal that remains is more heavy and compact. It contains no ſaline matter, having been waſhed before its diſtillation. It may be reduced to aſhes more eaſily than the coal remaining after the diſtillation of ſerum, and its aſhes, which became perfectly white, contain neither ſaline nor ferruginous matter.

Other experiments of M. *Bucquet* teach us that this fibrous part is not ſoluble in boiling water, which on the contrary, hardens it, and at the ſame time, gives it a grey colour. It is not ſoluble by ſpirit of wine, nor by oils, nor by the yolk of an egg, nor by alkalies, nor even by cauſtic alkali, which we have ſaid diſſolves the coagulum of the ſerum. But all acids, even vinegar, eaſily diſſolve this matter. It may be ſeparated from its ſolution in acid by water, and ſtill better by alkalis. Theſe are remarkable properties and are analogous to thoſe of the glutinous animal matter of flour, and of cheeſe.

The red part of the blood ſeparates ſpontaneouſly from the ſcum, and, as we have ſaid, may be eaſily ſeparated from the fibrous part by waſhing with water, in which it is perfectly ſoluble: the water in which this red part of the blood is diſſolved becomes of a deep red, and the matter diſſolved differs little, as Meſſrs. *Rouelle* and *Bucquet* obſerve, from ſerum. Like ſerum, it is coagulable by heat, by acids, and by ſpirit of wine; it is ſoluble by volatile alkali; and it yields the ſame products by diſtillation; its coal is equally light and charged with common ſalt and mineral alkali; but it is with difficulty reducible to aſhes, and theſe aſhes, which are of a brown red, like a martial crocus, owe their colour to the iron which they contain in very great quantity.

From

From these interesting experiments it appears that all the iron which is obtained in the analysis of blood, proceeds principally, if not solely from the red part; and they confirm the opinion of those who attribute the red colour of blood to this metal.

An observation in the practice of medicine, which is found to accord with this idea, is that the martial mineral waters, iron in substance, and in general all the preparations of this metal, a considerable part of which at least passes into the blood, as the experiments of M. *Menghini* shew, are the best remedies that can be employed in the chlorosis, in which disease we know that the blood is almost totally discoloured.

This red colour of blood is subject to some variations, in different circumstances. It is believed, not without probability, that the action of the air gives to it more lustre and vividness. It is certain that the blood of the pulmonary vein and of the arteries, is of a more exalted red than the blood of the veins; and Dr. Priestly has made curious experiments which shew very sensibly the great influence of the air on the red colour of the blood.*

B O N E S.

BONES are the most solid parts of animals, and they owe this solidity to the great quantity of earth of which they are almost entirely composed. They contain also (besides the fat part of the marrow, which are only interposed) a considerable quantity of the same animal gelatinous substance which exists in the flesh and in almost all the other parts of animal bodies. *See* JELLY.

This gelatinous matter may be almost entirely separated by long and strong decoctions in a large quantity of water, or by dissolving the earthy part in the nitrous acid diluted with water, as M. *Herissant* has done after *Stahl*. Combustion, or calcination to whiteness, is another more expeditious method of obtaining the earth of bones entirely deprived of all its gelatinous part, when the intention is only to examine this earth, the nature of which has been entirely unknown till lately.

Chemists might well be embarrassed with the earth of bones, as on the one side, it exhibits with acids all the phenomena of calcareous earths, and on the other side, it wants the characteristic property of these earths; namely, the property of being converted by fire into quick-lime. Accordingly, several opinions were formed concerning the nature of the earth of bones. Some chemists considered it

* Concerning the influence of air on the colour of blood, see the *Treatise on the various kinds of permanently elastic fluids*, page 112, second edition.

it as a combination of calcareous with argillaceous earth; others thought it resembled the magnesia of Epsom salt; and the most prudent remained doubtful, till further experiments should produce new light. These experiments have been made in Sweden, and published a few years ago. They consist in extracting from bones, even when they have been calcined to whiteness, by means of the vitriolic acid, a saline, fixed, and vitrescible matter, which acts as an acid: is analogous to that obtained from fusible, or phosphoric salt of urine; and like this salt, is capable of forming *Kunkell's* phosphorus, by combining with phlogiston.

I have only been informed of this discovery, by the *Gazette, Salutaric de Bouillon*, October, 1775. It is there said, that Mr. *Henry Gahn*, a physician at Stockholm, has communicated a process for extracting from bones the saline matter in question; and that Mr. *Scheele* had ascertained, that the earth of animals was composed of a calcareous substance united with the phosphoric acid. This discovery, continues the author of the article of the Gazette, belongs to Mr. *Gahn*, and has been confirmed by later experiments.

It appears then, that these two chemists partake equally of this discovery. I presume, that having applied vitriolic acid to the earth of bones in a sufficient quantity for the reciprocal saturation of the two substances, they have separated, by washing, the selenitic matter formed in the operation; and that after filtrating all the acid liquor, they have exposed it to evaporation. I believe also, that the Swedish chemists judged, from the liquor becoming thick towards the end of the evaporation, or from some other sign, that it was the same saline matter which is called phosphoric acid; for it was said by them, that when they mixed some charcoal powder with this matter, and distilled the mixture, a phosphorus similar to that from urine was obtained, by a heat not exceeding that which a luted glass-retort could bear.

Another process is also mentioned for extracting this phosphoric acid from bones. It consists in dissolving bones in nitrous acid, in adding to this solution vitriolic acid, till more selenites is precipitated, and in distilling, or evaporating the liquor, in order to expel the nitrous acid which is now become disengaged, and the excess of vitriolic acid, if there should be any. Thus is obtained a residuum similar to the preceding, and with which phosphorus may be also made.

These fine experiments shew, that the earth of bones is saturated, at least in part, with the same acid, or phosphoric salt, which acts as the acid in the fusible salt of urine. The Swedish chemists say, what is very true, that if phosphorus cannot be immediately obtained from bones, the reason is, because the salt, or phosphoric acid

engaged

engaged in a calcareous earth, or in a fixed alkali, cannot quit these bases to combine with the inflammable principle with which alone it can form phosphorus; and therefore the calcination of bones does not prevent the saline matter from being afterwards extracted from them by means of acids.

A discovery of this importance required to be verified with the greatest care, and accordingly M. *Poulletier de la Salle*, author of the French edition of the London Pharmocopeia, whose zeal and abilities are well known, and with whom I have the advantage of prosecuting chemical researches relative to medicine and animal oeconomy, having proposed to me to make this verification together, we attempted it, and after several trials, we obtained, from hartshorn calcined to whiteness, by the intervention of the vitriolic acid, the saline matter mentioned by Mr. *Scheele*, at first of the consistence of a syrup; and afterwards, by evaporating it to dryness, and melting it in a crucible, in order to purify it, it became a vitreous matter, which being mixed and distilled with powder of charcoal, yielded a very fine phosphorus, which Messrs. *D'Arcet* and *Rouelle* saw taken out of the receiver. I shall not enter here into the detail of the experiments and observations which we made on this matter, because our researches are not yet finished. But several chemists, especially M. *Rouelle*, and M. *Prouste*, a young artist of great hopes, being now also occupied on this subject, we have reason to hope for the knowledge of some interesting facts. I am informed by M. *Rouelle* that a larger quantity of phosphoric salt may be obtained from uncalcined, than from calcined bones. This quantity is not yet determined. But after what we have hitherto observed, I am inclined to believe that three or four ounces may be obtained from a pound of hartshorn. We do not yet know whether the bones of all animals yield this phosphoric saline matter, and in an uniform quantity. Many experiments, and much time are required, to decide these questions. The facts which are now ascertained by facts well verified are, that the earth of bones is essentially a calcareous earth, forming a selenites with the vitriolic acid, and calcinable into quicklime, after it had been separated from the vitriolic acid by means of a fixed alkali, and well washed; as M. *Poulletier* and I were convinced from our experiments; and that if it cannot be converted into quicklime while it is united with its acid or phosphoric salt, the reason is, because this saline matter, which is of itself very vitrescible, and capable of vitrifying other bodies, begins to vitrify the earth of bones, whenever it is exposed to the heat requisite to convert calcareous earth into quicklime.

These are the experiments which seem to prove that the earth of bones is essentially calcareous, or at least that it is mixed with a large quantity of true calcareous earth. That we might know whether the earthy salt, almost insoluble in water, which we had obtained

obtained from mixing vitriolic acid with earth of bones, had the marks of ordinary selenites; after we had well washed this matter, we digested it during two hours with a lixivium of pot-ash, which did not appear to produce any sensible effect. We then filtrated and evaporated the liquor, by which means we obtained a laminated salt, which appeared to us to have all the characters of vitriolated tartar.

The earthy matter which remained upon the filter, was very white, friable and insipid. We calcined it during two hours with violent heat in a German crucible placed in an air-furnace. After this calcination, this matter was white, moderately agglutinated into a mass at the bottom of the crucible. It had an acrid alkaline taste. It was not much diffused by pouring on it distilled water; but this water thereby acquired the acrimony of lime-water. We filtrated it, and added to it some mild fixed alkali, upon which it deposited a copious white precipitate, as lime-water does. Lastly, a crust was formed on this water, like the cream of lime.

Although the calcination which we effected of the earth of bones deprived of its phosphoric acid, and of the vitriolic acid employed in the process, was not complete, since its extinction in water was not accompanied with heat, the marks of quicklime which we observed, are sufficiently sensible, to shew that this earth is essentially of calcareous nature, and that if in its natural state it does not exhibit all the marks of calcareous earth, the reason is because it is combined with phosphoric salt or acid.

Does not saline matter fit for making phosphorus, found first in human urine, and now in bones of animals, reside in many other animal substances? Experience alone can ascertain this point. *See the Article* PHOSPHORUS *of* KUNKEL, for the properties of the phosphoric acid.

Addition to the Article BORAX, *of the former Edition.*

BORAX. Notwithstanding the experiments which have been made on borax and the sedative salt, chemists are not yet decided in their opinions concerning the nature, principles, and even some of the properties of these saline substances. This uncertainty induced Messrs. *Cadet* and *Beaumé*, both of the academy of sciences, to apply their researches upon this subject. But as these two chemists do not agree, neither in all the facts which they relate, nor in the consequences to be deduced from these facts, I will only relate in a summary manner the results of their experiments, without giving any preference to the opinion of either, because I think, that in fact several of the contested points are still doubtful, and cannot be cleared up without further experiments.

M. *Cadet*

M. *Cadet* preferred the crude borax to the refined as the subject of his experiments, and the kind which he used is that known in commerce under the title of *Borax of China*. From this borax he separated by means of solutions and filtrations a whitish earth, on which he made many experiments, which are related in the fifth volume of the *Memoires des Scavans Etrangers*. One of the most remarkable of these experiments is that, in which he obtained from this earth a regulus of copper, which he deposited with the academy. M. *Cadet* thinks that this regulus is one of the principles of borax or of sedative salt. Mr. *Beaumé*, on the contrary, is of opinion that this metal is only found accidentally in borax, and that it proceeds from the vessels in which this saline matter is prepared. The proof of this is, that in whatever manner pure borax is examined, it gives no mark of copper. M. *Cadet* answers these objections by experiments which shew that copper may be so disguised by its union with different saline matters, that it cannot be discovered by the ordinary trials; and especially by the action of volatile alkali, which is the usual, and thought to be the most certain. The different combinations which he made of copper led him to the composition of a kind of artificial borax, which has the property of soldering well silver and copper. He announces that he has made on this subject some new experiments, which he will soon publish.

The earth which is separated from crude borax, during its purification, contains, according to M. *Beaumé*, much sedative salt. He has extracted some of this salt from that earth by the ordinary method of solution, filtration, evaporation, &c. but more easily by addition of an acid. M. *Beaumé* has also ascertained, that even in the decomposition of refined borax, a small excess of acid favours much the separation and crystallization of the sedative salt. But M. *Cadet*, although he agrees with M. *Beaumé* in the good effect of an excess of acid in operating upon borax, is not of the same opinion respecting the earth of crude borax. He affirms, that having made repeated lixiviums of large quantities of this earth, these lixiviums when filtrated and evaporated did only yield a pellicle with rain-bow colours on the surface of the liquor, and even that this pellicle was not sedative salt, but a matter which, when perfectly dried, was quite insipid, and as little soluble in water as selenites and gypsum. M. *Cadet* adds, that when these lixiviums of the earth of borax are evaporated, if the pellicles are allowed to precipitate, instead of removing them as they form, the liquor acquires a colour towards the end of the operation, and also an urinous smell; at which time, he says, all the pellicles, which had precipitated, disappear entirely, the liquor acquiring then the taste of borax, and really containing a certain quantity of this saline matter, which may be thence obtained by crystallization.

M. *Cadet*

M. *Cadet* concludes from theſe experiments, that the earth in queſtion is nothing but borax, the aggregation of whoſe parts had been broken and diſunited by the water, and whoſe regeneration is effected by the ſame means by which it had been decompoſed.

Mr. *Beaumé* agrees that ſome borax may be obtained from the earth that is ſeparated in the purification of that ſalt; but as it is only by means of the portion of ſedative ſalt which it ſtill contains, it is neceſſary, he ſays, to add to it a quantity of mineral alkali proportionable to the quantity of ſedative ſalt, and ſufficient to ſaturate it, and reduce it to borax. Mr. *Beaumé* concludes from thence, that by adding at firſt a ſufficient quantity of mineral alkali to the lixiviums made of crude borax, in order to purify it, the whole quantity of the borax may be at once procured, the earth containing one of its principles.

Before M. *Baron* had publiſhed his memoirs on borax, nothing was known deciſively on the nature and pre-exiſtence of ſedative ſalt in borax. *Homberg* and ſeveral other chemiſts have thought that the ſedative ſalt was compoſed partly of the acid employed in the proceſs for obtaining it. But ſince M. *Baron* has made his experiments, moſt chemiſts have been of opinion with him, that ſedative ſalt exiſted ready formed in borax, that acids do nothing but ſeparate it from the mineral alkali, do not enter into its compoſition, and that conſequently there is but one kind of ſedative ſalt, this ſalt being always the ſame, whatever acid may have been employed to diſengage it.

On this important point, M. *Cadet* has declared himſelf to be of the opinion of thoſe who, before M. *Baron*, believed that the ſedative ſalt was a new compound, reſulting from the union of certain principles contained in borax with the acids employed in the proceſs. Beſides the experiments which he has already publiſhed in ſupport of this opinion, he hopes to prove ſhortly, "That ſedative ſalt is not ready formed in borax, and that it partakes "not only of the acid employed to diſengage it, but alſo that "it contains a portion of the baſis of ſea-ſalt contained in "borax, and that it is owing to this ſame alkaline baſis, "that cream of tartar owes the ſolubility which it acquires when "combined with ſedative ſalt in the new neutral ſalt of M. *de la* "*Sone*, which M. *Cadet* conſiders as a compound, conſiſting of "five different principles. (Mem. de l'Academ. 1766, p. 365.) "Sedative ſalt, according to M. *Cadet*, may be combined in ſeveral "different modes with different ſalts, which when thus combined "do not ſhew their properties by the uſual methods of diſcovering "them. For inſtance, he combined ſedative ſalt with pure nitre, "and in this compound, he could eaſily diſtinguiſh the peculiar "cold taſte of nitre. He obſerved alſo, that by ſolution and cry-

"ſtalliza-

"stallization, he could separate the crystals of nitre. But never-"theless, this compound does not fuse on burning coals, nor by "this method yield any fixed alkali, as M. *Cadet* says."

M. *Beaumé*, however, maintains firmly the opinion of M. *Baron*. He not only affirms that sedative salt exists ready formed in borax, but he also announces, that by following one of the processes mentioned in Mr. *Pott*'s dissertation, he has been able to make sedative salt, by combining the acid of fat with an argillaceous earth, by means of a digestion or maceration of a mixture of fat and clay continued during several years, in which mixture neither the acid nor the basis of sea-salt entered.

Ever since sedative salt has been known, it has been suspected, that it contained an acid. Most chemists have believed that this acid is the vitriolic, although some, as professor *Meltester*, M. *Bourdelin*, and M. *Cadet*, are of opinion, that it is the marine. M. *Cadet* mentions some effects on metals produced by marine acid, and calls to support his opinion, the fine experiments of M. *de Lassone*, related in the memoirs of the academy of sciences for 1757, in which we are told that a salt very similar to sedative salt was obtained in a combination with marine acid.

M. *Cadet* is convinced from many experiments, particularly by washing sedative salt with so great a quantity of water, that of fifteen ounces of salt, one only remained, which he drained carefully on blotting paper; that this saline matter does always retain an excess of acid, turns to red the blue colours of vegetables, and makes a sensible effervescence when united with an alkali. He maintains that this excess of acid is common to all sedative salts, with whatever acid they may have been prepared. But this able chemist announces at the same time, that he will soon prove that these sedative salts differ from each other, according to the kind of acid employed in their preparation, and that the sedative salt, or the materials of which it is formed, do not constitute one half of the whole quantity of matter contained in borax, as M. *Beaumé* had said. Finally, the later observations of M. *Cadet* turn upon the combinations of different sedative salts with the several kinds of alkalies, mineral, vegetable, and volatile, whence he formed different kinds of borax, all which are capable of soldering, more or less perfectly. Sedative salt alone has this property, as M. *Cadet* has observed.

CALXES (METALLIC). By this name are distinguished the *earths* of metals deprived of phlogiston and charged with gas. They may be deprived more or less of the inflammable principle by several means.

The first is by disengaging their phlogiston in open air, and by a *calcination*, or rather by a *combustion*, similar to that of all other combustible bodies.

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The ſecond is by expoſing metals to the action of acids that are capable of taking from them the inflammable principle; and of communicating to them a gas. Such are the vitriolic, and eſpecially the nitrous acids. This kind of calcination is made in the humid way, and by *ſolution*.

Laſtly, the third method is by detonating the metallic matters with nitre. This method depends on the two former ones, is the moſt effectual, and moſt expeditious.

The earths of metals thus calcined and deprived of their phlogiſton, and charged with air or with gas, by the means above mentioned, have properties which diſtinguiſh each of them, concerning which, it is proper to conſult the article of each of the metallic ſubſtances. But they have alſo properties which are general and common to them all.

Metals do not only loſe their characteriſtic properties as metals by calcination, but they alſo ſuffer the following changes:

The more exactly the metallic matters are calcined, the more they loſe of their fuſibility; ſo that ſubſtances which are very fuſible, ſuch as tin and regulus of antimony, are rendered, by a compleat calcination, that is, till they become very white, infuſible, and among the moſt refractory bodies; which fact proves that phlogiſton is the principle of the fuſibility of metals.

Metallic ſubſtances become then ſo much more fixed, as they loſe more of their phlogiſton. This property is leſs ſenſible in metals, from the fixity which they have naturally, than in ſemimetals, which are volatile, while they have their metallic form, and whoſe calxes become exceedingly fixed, as appears evidently in the inſtance of diaphoretic antimony, which reſiſts the moſt violent fire without ſubliming, and which recovers all its volatility when it is reſtored to the ſtate of regulus by addition of phlogiſton. This proves that phlogiſton is eſſentially volatile, and that it communicates its volatility to certain bodies with which it combines.

Metallic earths become leſs ſoluble in acids, and particularly in nitrous acid, by being deprived of phlogiſton, as we may perceive from crocus martis, when well calcined, from calxes of tin, of regulus of antimony, &c. Hence we are led to conclude, that the ſolubility of metallic ſubſtances by acids, and particularly by nitrous acid, depends on the intervention of phlogiſton: for if calxes be reduced by adding phlogiſton, the metals reſulting from that reduction will then recover their ſolubility.

What we have ſaid concerning the general changes produced by calcination of metallic matters, upon their fuſibility, their fixity, and ſolubility, may alſo be applied to their opacity, their ſpecific gravity, in a word, to all their metallic properties, which are always diminiſhed ſo much more in metallic calxes, as they are more perfectly dephlogiſticated. This ſeems to indicate, that if an

an entire and perfect calcination of metallic substances could be effected, they would then have no metallic property, and perhaps they would not specifically differ from each other, and only be one and the same kind of earth. This is certain, that when the calcination of metals has been too long continued, their calxes become irreducible, or at least with much more difficulty reducible; and this reduction is always made with loss, so that the quantity of metal originally calcined is never again obtained.

Although metallic calxes are essentially different from calx of stone or quicklime, they have nevertheless some similar properties, particularly those which relate to fixed and volatile alkalies. Thus, for example, fixed alkalies receive from metallic calxes, the same causticity and properties as from quicklime; and volatile alkali may be separated from sal ammoniac by metallic calxes, and particularly by minium, as it may by quicklime; and it is thereby rendered more active and deliquescent. We have seen at the beginning of this article, that there are several methods of reducing metallic matters to a calciform state. All these calxes have common properties, which are those I have mentioned, but they have also properties peculiar to each, according to the nature of their respective metals, and also perhaps according to the methods used in their preparation. But the true cause of these differences, or even the true state of metallic calxes, are very far from being known. This subject, which would furnish matter for very important researches, has scarcely been touched upon, and may be considered as entirely new.

A very few modern chemists only have begun to consider it. They have chiefly attended to one striking phenomenon, which appears to affect metallic calxes in whatever manner the metals may have been calcined. I mean the weight acquired by most metals during their calcination. I say only *most* metals, because it is not yet proved that this effect happens to all. But since it has been actually observed in many of them, we may suppose that this phenomenon is general, as is well explained by M. *Morveau*, who possesses the true genius of natural philosophy and chemistry. Let us describe this phenomenon. If we reduce a metallic substance to an earthly state, either by burning, that is, by calcining it, or by dissolving it in some chemical agent, and afterwards precipitating it from that solution, we may observe very generally, that the absolute weight of the earth or calx which results from this operation, is greater than that of the metal before it underwent this alteration; and on the other side, when these calxes are by any means restored to their metallic state, it is found that this augmentation of weight ceases, so that the metal thus revived, weighs rather less than more than it did before its calcination. Various opinions have been formed concerning the cause of these very

very surprising effects. *Lemeri*, who was unacquainted with the doctrine of phlogiston, explained all this easily, by saying that the augmentation of weight of metallic calxes arose from the particles of fire, which he supposes united with these calxes. *Meyer* and his partisans, although they were acquainted with, and admitted the theory of phlogiston, explained no less readily the above described phenomena, by attributing them to the *acidum pingue* or *causticum*, which they carefully distinguish from the inflammable principle. But other philosophers, not well satisfied with these suppositions, which seemed not sufficiently supported by proofs, have recurred to theories more laboured, and which are at the same time compatible with the doctrine of phlogiston. One of the most ingenious of these theories, is that in which fire and phlogiston are considered as a matter not possessed of weight, or rather as possessed of a property contrary to gravitation. This idea has been unfolded, and supported by proofs by M. *Morveau*, in a manner very capable of making an impression on the best understandings. But it is easy to perceive how difficult it is to arrive at evidence and demonstration in a matter so obscure as this is at present.

Since the late researches into gases, the idea of these fluids being concerned in the calcination of metals, and in the augmentation of weight gained by that operation, has been suggested. Dr. *Hales* had observed, that metallic calxes contained *air*, and that this air contributed to their augmentation of weight. Dr. *Priestley* has also made several experiments tending to establish this fact. But we are chiefly indebted to Messrs. *Lavoisier* and *Bayen* for a number of experiments made on this subject. M. *Lavoisier* considering the known phenomenon of an effervescence, which always accompanies the revival of a metallic calx, suspected, with much probability, that this effervescence was caused by the disengagement of a gas which separated from the metallic calx when it resumed the state of metal; and in order to be convinced of it, he made many reductions of minium in close vessels, to which was adapted an apparatus for receiving and measuring the gas expelled during these reductions. The quantity of gas was found to correspond pretty exactly with the excess of weight which the minium had over the lead whence it was prepared, and with the loss of weight which the minium suffered during its reduction into lead. Also, the loss of weight sustained by the charcoal employed in these reductions, was scarcely sensible when compared with the quantity of gas produced. The same results nearly followed from reducing metallic precipitates. Lastly, the examination of the properties of the gases disengaged in these several reductions, when made by means of a combustible matter, having convinced M. *Lavoisier* that they were the same as that obtained from calcareous earths and alkalies, he has thence concluded, with much probability, that

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the increase of weight gained by metallic earths, is owing to an aerial matter, or gas, which is united with them, and which contributes to their state of metallic calxes.

It is natural to any person who makes an important discovery, to consider the consequences which may be deduced from it, especially when these consequences happen to overthrow a famous and received theory, because these discoveries thereby become more important. Accordingly, M. *Lavoisier*, when he published the above mentioned experiments, appears to have been tempted to infer from them, that the metallic state of calxes was owing merely to their being united with a considerable quantity of gas, and that nothing more is required to restore them to their metallic state, than to deprive them of this matter; which opinion, if it were proved, would destroy the whole doctrine of phlogiston or combined fire. Nevertheless, this able philosopher has resisted, at least hitherto, that temptation, and has refrained from an absolute decision on this delicate question. His prudence deserves the more praise, as it shews him to be possessed of the true spirit of chemistry. For in fact it is only they who do not really know this excellent science, who can imagine that such inferences can be readily drawn, and that a single fact, even supposing it were well established, could be sufficient thus at once to overturn the fine fabric of one of the most important theories which the genius of chemistry has ever erected, and which receives from an astonishing number of demonstrative experiments, a support and strength, which must appear irresistible to those minds who are able to comprehend the whole, and their relations in one collected view.

M. *Bayen* also, well known by several good analyses of mineral waters, has lately published in the Abbé *Rosier*'s journal, some experiments which are analogous to those of M. *Lavoisier*, and has drawn from them similar consequences, which appear to him to be very decisive. The title of Mr. *Bayen*'s desertation is, *Chemical Essays, or experiments made on some mercurial precipitates.* It is well known that mercury exhibits phenomena similar to the calcination of other metallic substances, in the preparation of the *precipitate per se*, and in the solutions of mercury by acids.

M. *Bayen* has preferred these calxes of mercury to minium and other metallic calxes as the subjects of his experiments, and in this respect he had an advantage over M. *Lavoisier*, because the mercurial calxes resume their metallic state with much less heat, and thereby many of these operations are facilitated, the principal difficulty of which arises from the necessity of using close vessels, in order to retain and collect the gas that is produced during these reductions.

M. *Bayen*'s experiments consist in exposing mercurial precipitates to the action of fire, in retorts to which was adapted an apparatus

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of receivers for collecting and measuring the gas produced. The precipitates of mercury which were the subjects of his experiments, were separated from the solution of this metallic matter in the nitrous and marine acids, by means of alkalies fixed and volatile, caustic or not caustic, and by quicklime or lime-water.

This able chemist treated these different precipitates in his pneumato-chymical apparatus, with different degrees of heat, without addition, and likewise with addition of powder of charcoal.

In each of his experiments he obtained, first, a portion of the solvent and precipitant employed; Secondly, a quantity greater or less of revived mercury, or fluid quicksilver; Thirdly, more or less of a gas, the quantity of which was proportionable to the quantity of revived mercury. And it was also observed, that in those cases where the calxes were totally revived, the quantity of fluid quicksilver obtained, was always one eighth or one tenth less in weight than the quantity of the precipitate before its reduction, allowance being also made for the excess of weight which these precipitates gained from the portion of chemical agents that they retain in their precipitation.

These fine experiments of M. *Bayen*, gave him an opportunity of making other interesting observations; such as, the inflammation, explosion, and fulmination of the mercurial precipitates, when they are first mixed carefully with a certain proportion of flowers of sulphur, and then exposed to heat. He also observed the remarkable effects of fixed and volatile alkalies, which did only partially decompose corrosive sublimate, and converted the rest of it into sweet mercury, while lime-water procured a much more complete decomposition of this mercurial salt.

The phenomena of the reduction of mercurial precipitates, with regard to the production of gas, and the difference of weight, are analogous to those which M. *Lavoisier* has observed, by reducing minium in close vessels. M. *Bayen* had deduced the same consequences, namely, that all metals reduced to the form of earth, or of calx, owe this state to the gas which unites with them during their calcination by fire, or by chemical solvents; that to this substance the augmentation of weight is to be attributed, which they acquire during their calcination; and that this gas separates from them during their revival. These consequences resulting naturally enough from the accurate experiments of these two philosophers, appear to me very probable, and seem to announce an important discovery.

But these able chemists have gone a good deal further. I have already said, that M. *Lavoisier* had conjectured from his experiments, that the inflammable principle does not contribute materially, and by its direct union, to metallic reductions; and I ought to add, that M. *Bayen* having been able, in the course of his experiments,

, by means of a stronger or longer continued heat, to re-
ally, or almost totally, a precipitate of mercury into fluid
ver, without addition of any inflammable matter, did at
cide, from this single fact, in favour of the conjecture pro-
y M. *Lavoisier*, as if it were a demonstrated truth, which
to overthrow the whole doctrine of phlogiston, or of fire
ed in bodies.

ithstanding the sincere esteem which I have for the talents,
the fine experiments of M. *Bayen*, I must say, that he
ded too precipitately on an affair of so much importance;
n the more surprized at this, as in every other part of his
, he shews the most rational doubt, and most judicious cir-
ction. "The following experiments (says M. *Bayen*,) will
eive us with regard to the doctrine of *Stahl*; in relating
, I shall not make use of the terms used by the disciples of
who will be forced to relinquish their doctrine on phlo-
, or to maintain that the mercurial precipitates here men-
d, are not metallic calxes, although some of their most ce-
ed chemists have thought that they are; or lastly, to con-
hat there are some metallic calxes which can be reduced,
out the concurrence of phlogiston."

experiments to which M. *Bayen* here refers, are the re-
of mercurial precipitates without addition of inflammable
in close vessels. To shew that they are by no means
of affecting the doctrine of phlogiston, so well established
, confirmed and explained so successfully by chemists of
order, it will be sufficient to observe, first, That al-
it were proved that mercury, silver, and especially gold,
ey are reduced to the form of calxes and precipitates, did
any thing of their inflammable principle, this would not
doctrine of the principle of inflammability, since the only
ence would be, that in some metals, this principle is so
ly connected and combined, that they can resist opera-
hich the other metals cannot, without being decomposed;
h has been said to be the case since phlogiston has begun
lked of, and which is in a great measure true. Secondly,
on the contrary, it were proved, that mercury, silver, and
ld, lost a part of their phlogiston, as well as the other
(which is M. *Beaumé*'s opinion, and which I believe to
possible,) the reduction of these metallic matters in close
and without addition of inflammable matter, would not
r oblige us to relinquish any part of the theory of the prin-
inflammability. For it would be a sufficient explanation
ose, that the quantity of this principle which gold, silver,
rcury can lose, in the operations by which these metals are
to the form of calx, is so small, that the quantity of

metal

metal which cannot be reduced from want of addition of phlogiston, is so infinitely little, in comparison of the quantity of the rest of the metal which is reduced, without having any occasion for addition; that we might be induced to believe that the whole of the metal had been reduced, although some may actually remain unchanged.

Let us even go so far as to suppose, that these metals are much more susceptible of calcination than they have been hitherto believed to be, and that nevertheless, they may be totally revived in close vessels, without addition of inflammable matter? How would this supposition make against the doctrine of phlogiston? Nothing else can be inferred, unless that this is one of the cases in which the disengaged fire may be changed into combined fire. The partisans of the theory of *Stahl* will always say, that these metals cannot take the form and the properties of metallic calxes, without losing a part of their phlogiston, and that if they have recovered their metallic properties in close vessels, without addition of inflammable matter, the reason is, that disengaged fire, or the matter of light, which is necessary in all these reductions, and which penetrates both close vessels, and the metallic calx, finds in this calx, a body which already contains a good deal of it in the state of combination, and which has the greatest aptitude to resume and retain enough of it to recover its metallic state. Whence it happens that a portion of the light with which it is penetrated in the operation itself, is fixed in its union, becomes phlogiston, and again restores the metallic state. What reply can one make to those who will thus explain the fact in question? I own I know of none, and I believe that we may thence conclude, that neither the reductions of metallic calxes in close vessels, without any other addition than that of the disengaged fire with which they are penetrated, nor the proofs of the existence of a gas in these calxes, and of its expulsion during their reduction, do affect in any degree the theory of phlogiston, and while no other facts more decisive can be adduced in opposition to it, those who admit it, will not be inclined to make any change in the established language, nor the slightest restriction to their doctrine.

With regard to the gas, which appears to be in a great measure, the cause of the augmentation of weight of metallic calxes; because *Meyer* says, that his *causticum* or *acidum pingue* does also unite to these calxes, M. *Bayen* is much inclined to consider gas and causticum to be the same thing. The circumstance which seems to favour the opinion of *Meyer* is, that most metallic calxes have a degree of causticity, which they are capable of communicating to alkalies, particularly to the volatile alkali of sal ammoniac, when it is disengaged by their means. But besides, that quicklime, so far from communicating a gas to other matters, as metallic

calxes do, is on the contrary very much disposed to be united gas, and to lose its causticity by this union; it is sufficient to re the properties which *Meyer* attributes to his causticum, hose which have been ascertained to belong to all the gases, specially to that of calcareous earth, to be convinced of the al differences, and even of the incompatible qualities which e observed in these two substances.

reover, there is a circumstance in the reduction of mercury e vessels, which was not known to M. *Bayen*, because he did amine the nature of the gas obtained in his experiments: is circumstance deserves the greatest attention. It consists , that the gas obtained from mercury during its revival with on of inflammable matter, is totally different from that which ngaged from the same mercurial calxes, revived without n. The former gas extinguishes fire, and kills animals ineously, while the latter is five or six times fitter for respirad combustion than the atmospherical air. Whence can so ous a difference proceed? It certainly has some cause, and use must be a very powerful one. The gas which is disen- during the reduction of mercury with addition of inflammatters, seems to be of the same nature as that of calcareous , of alkalis, of the spirituous and other fermentations, has been called *fixed air*;* and which I call *mephytic gas*.

the nature of this gas not being understood, may we not ture, that the principle of inflammability is one of its constiparts, together with common air; and if this be the case, it well separate from the mercurial calxes, without suffering eration, when this separation is assisted by a combustible , which gives to the mercury the quantity of phlogiston that essary, in order to reduce it into fluid mercury; but when alxes are exposed to violent heat in close vessels without n, then their reduction into fluid mercury, is effected only eans of the phlogiston of the gas which is united with the , and according to this supposition, we easily conceive, that s deprived of the phlogiston which mercury has taken from s reduction, ought to approach to the state of common air, n air so much purer, as it may have been more perfectly ogisticated in this operation. The name of *dephlogisticated* which Dr. *Priestley* has given to this excellent air separated metallic calxes reduced without addition, would perfectly with it, and these reductions of metallic calxes, without on of inflammable principle, would not in this supposition h any objection to the theory of phlogiston. A further probability

* is described in the Treatise on Gas, under the name of cals gas.

bability is given to this idea, by confidering that the reductions of metallic calxes without addition of combuftible matter, are much more difficult, and require a much greater heat, than thofe which are effected in the common method, by means of fome inflammable matter. Thefe are indeed only conjectures, and even are but little fupported by experiment, the prefent ftate of our knowledge of the fubject of gas, not admitting any thing much more accurate; but they are neverthelefs at leaft *poffible*, and are not inconfiftent with the great phenomena of chemiftry.

We may therefore conclude, that nothing has been yet alledged which is capable of fubverting the theory of phlogifton. *See the articles* CAUSTICITY, QUICKLIME, FIRE, GAS, PHLOGISTON, *&c.*

CAUSTICITY. Caufticity is that fharp and corroding quality, which many fubftances poffefs, fuch as the mineral acids, efpecially when concentrated, alkalies fixed and volatile, quicklime, arfenic, corrofive fublimate, lunar cryftals, butter of antimony, and even moft other falts with metallic bafes.

All thefe fubftances when introduced into the ftomach and inteftines of animals in a fufficient quantity, according to their refpective degrees of ftrength, affect the animals who have taken them more or lefs difagreeably, fometimes give violent pain, and occafion death. When we confider only their malignant effects, we call them *poifons*, or *corrofive poifons*, to diftinguifh them from other deadly fubftances, in which a corrofive quality is not fenfible.

The fame fubftances applied externally upon the fkin, and the flefh of animals, excite inflammation, and pain fimilar to what is occafioned by fire. They produce efchars, fuppurations, corrofions, excavations, and eat away the flefh. As from time immemorial, thefe matters have been ufed in medicine and furgery, to draw the humours to the external parts of the body, there to excite falutary fuppurations, to open abfceffes, or to confume excrefcencies and proud flefh, and that independantly of the fenfation of burning, which they occafion, they produce in fome refpects the effect of a body actually burning, they have been called *cauftics*, and thence the word caufticity has been derived.

Laftly, when thefe acrid fubftances are applied to unorganized bodies, fuch as all bodies excepting animals and vegetables, they fhew evident marks of their peculiar action, by the motion, effervefcence and heat, which are excited in fuch mixtures. And as after thefe figns of re-action are over, we find that all the integrant parts of the body acted upon, have been feparated from each other, and combined with thofe of the cauftic fubftance, fo that there has happened a folution of the former, and an union of its parts with the latter into a new compound; in confidering the acrid

and

caustic substances, with relation to their effects in chemical ations, they have been called *chemical agents*, or *chemical solvents*. ence it follows that the action of corrosive poisons, of caustics, of chemical solvents, is essentially the same, and that it may omprehended under the general name *Causticity*; and, that causticity is nothing but the dissolving action of the caustic ances, that is to say, it is the force with which their integrant tend to combine, and unite with the parts of other bodies.

indeed, if we examine the stomach and intestines of ani- killed by corrosive poisons, and the wounds to which sur- have applied caustics, we find that the animal matters have more or less corroded, consumed, and dissolved; and that oison or caustic has really combined with the oily, saline, y, watery, and gelatinous parts of the organs on which it and that it has formed new compounds with these parts, sely in the same manner, as when aqua-fortis has acted upon e of iron, we find that the surface of this iron is corroded, ved, hollowed, and that the parts of the aqua-fortis have d with those of the iron into a new compound.

e causticity and dissolving power of all chemical agents, being ad the same quality, and being also the proximate cause of compositions and combinations, natural or artificial, we may perceive the importance of having clear ideas of whatever has on to causticity, of knowing, as far as we can, wherein it s, how to augment, diminish, produce, or destroy it in a nce. But this is no small difficulty; for whatever is con- , as causticity is, with the first springs of the universe, is inaccessible to the efforts of the human mind. In such sub- we can only form conjectures; which are not, however, ut their use, when they can connect a great number of facts, ew the analogy and relations, which subsist between them.

losophers did not endeavour to explore the cause of cau- , till some of them began to reason upon the great phenome- chemistry. The most natural idea, and which must first t itself, was to attribute this quality to the presence of the of fire, on account of the striking resemblance between the of fire, and those of caustics, or chemical agents. Accord- this opinion was first adopted, and is even now very gene- eceived by those chemists, who wish to have a decisive opi- n this subject. The fine theory of *Stahl* concerning phlo- or concerning the effects of fire considered as one of the ples of combustible bodies, has not a little contributed to con- his opinion. In fact, we cannot doubt that fire possesses ity in the most eminent degree, and that it is the most pow- of all caustics, and since it is proved, that fire enters and self as a principle in many compound bodies, and is always

ready to resume its essential activity, entirely or partly, according to circumstances; nothing is more natural than to attribute to the action of igneous particles, the causticity of all those substances, which possess this quality. Lastly, it is very possible, and even probable that fire contributes directly, and by its own causticity, to that of certain bodies, and in certain circumstances, as I shall explain more fully. Accordingly *Lemeri* has attributed the causticity of quicklime, of alkalies, of acids, &c. to the igneous particles inserted between the parts of these substances. But this man, justly celebrated as a practical chemist, had the fault of attempting to explain every thing; and he did indeed explain every thing with great ease, because his explanations were not examined with accuracy or depth, and he adopted readily whatever ideas were suggested by first appearances.

This explanation of causticity by the particles of fire, which *Lemeri* supposed to be contained in caustic substances, would have remained among the many conjectures, which being neither evinced by solid proofs, nor confuted by demonstrative experiments, are supported by an air of probability, which satisfies many persons, if the late M. *Meyer*, a very good chemist of Osnabruck, had not endeavoured to place it amongst those great theories, which stand the test of examination, and which throw much honour on those who support and establish them, by all the proofs of which they are capable. M. *Meyer* has done every thing that could be done for that purpose. An exact inquiry into the properties of lime-stones, into the phenomena of their calcination, into the effects of the causticity of quicklime, and of the causticity which it communicates to alkalies fixed and volatile, into the manner in which these several substances acquire and lose their causticity; many new experiments, and many chemical facts, before known, but now brought into one point of view with genius, and profound reasoning, are become, in M. *Meyer*'s work, the basis of a system, which he has rendered his own. This system, which at bottom is only the explanation, which we have said was before given by *Lemeri*, consists in establishing, that there is only one substance essentially caustic; that this substance is the matter of fire or light; that all caustic compounds owe their causticity to this principle; that they lose this quality in proportion as they are deprived of it, and become more caustic when they combine with a larger quantity of it. What M. *Meyer* has added to *Lemeri*'s explanation is, that he does not suppose with *Lemeri*, that fire, absolutely pure, can combine in bodies, so as to become the principle of their causticity; but fire connected in a certain degree with a particular matter of an acid quality, and forming with this acid a kind of compound principle, in which the matter of fire, without having the activity of pure and disengaged fire, does nevertheless preserve

activity

ivity enough to be highly caustic, and to be capable of communi-
cating this quality to the different bodies, with which it is capa-
e of combining. Thus is constituted what he calls *acidum pingue*
causticum. The most seducing part of M. *Meyer*'s attempt, is,
at in his experiments, he has traced, with a good deal of saga-
y, the progress of this pretended causticum, from one combina-
n into another, observing the changes, which happened in the
operties of the body which transmitted it, and in those of the
dy which received it, as *Stahl* has done, with regard to phlo-
ton or perfectly combined fire.

A system founded on one part, upon natural effects no less sen-
le to the ignorant than to the learned, and supported on the other
rt, by a well-contrived course of chemical experiments, as M.
yer's was, could not fail to have many partizans. It accord-
gly so happened. Most German chemists, among whom is M.
rner, the translator of this Dictionary into the German language,
ve adopted, and warmly defended it. Several good French
actical chemists, have declared themselves in favour of it. M.
aumé in particular, is so pleased with it, that this able chemist
s made it the basis of all the explanations that are given in his
ymie experimentale et raisonnée. But in order to extend its use as
uch as possible, M. *Beaumé* has not confined himself, as M.
eyer did, to consider as the sole *causticum*, or principle of all
usticity, nothing but the matter of fire connected to a certain
gree with a particular acid; but he rejects the *acidum pingue* of
. *Meyer*, and declares that it is fire itself, as fire, which is the
e caustic and principle of all causticity; that this element may
, and actually is found in every kind of combination, from the
ost gross, which is that of oils, of charcoal, of metals, &c. to the
te of fire, pure, or almost pure, which he supposes to be its state
the most violent caustics, as the mineral acids, quicklime, caustic
kalis, and other substances. As in fact fire is spread every where,
thus supposing it may have different degrees of combination,
e may, with the utmost facility, explain a great part of chemical
enomena. Thus, for example, if limestone should, from being
ild and in no degree caustic, become acrid, caustic, and active,
having been exposed to fire, M. *Beaumé* sees clearly, along
ith *Lemeri*, that the cause of this surprising change, consists in the
troduction of the particles of fire, between the particles of the
nestone. All the causticity of quicklime, the heat which it
xcites when mixed with water, its saline properties, &c. are
used by a quantity of pure, or almost pure fire, that combines
ith the stone during its calcination. If fixed and volatile alkalis
ecome more caustic and deliquescent by application of quicklime,
nd if quicklime loses its causticity in proportion as it augments
at of the alkali, M. *Beaumé* presently understands, as also does
M. *Meyer*,

M. *Meyer*, that the alkalies takes possession of all the causticum, or almost pure fire which was contained in the quicklime. If the mineral acids are very caustic, it is because they contain much of the causticum of *Meyer*, or of the almost pure fire of *Beaumé*. If we ask Messrs. *Meyer* and *Beaumé* why acids, which are very caustic on account of their contained causticum and almost pure fire, should, when they combine with quicklime and alkalies, which also owe their causticity to the same igneous principle, form a compound which retains little or no causticity, they immediately answer, that the causticum or almost pure fire, separates from these caustic substances in the time of combination, and they adduce as a proof, the heat observed in the time of their action on each other. M. *Beaumé* has even provided himself with one resource more than M. *Meyer*, to extricate himself from this embarrassment, which is, that as he admits fire in all kinds of combinations, he may also say, that the cause of the above-mentioned phenomenon is, that the almost pure fire of the acids and alkalies, puts itself into another state of combination, different from that in which it existed while it was united with the disengaged acids and alkalies.

As every caustic has a most violent taste, and as the most caustic substances are also those which make the strongest impression on the organs of taste, it is very probable, that causticity and taste are essentially one and the same quality, as I have observed in several places. But this quality, being susceptible of greater or less degrees, preserves the name of causticity when it is strong enough to occasion pain, and acquires the name of taste when it has only strength enough to make a sensible impression on the organ, without the sensation of pain. If fire be the only caustic substance in nature, it follows, that this element is also the only matter which can have taste; that it is the principle of taste, and to which all other matters owe their taste. Accordingly M. *Beaumé* has not failed to advance this proposition, and makes very great use of it in explaining an infinite number of phenomena, and of the properties of bodies. Thus the taste which all saline substances have more or less sensibly, and which is considered as one of their distinguishing characters, proceeds, according to M. *Beaumé*, from this cause, that all saline matters contain fire, either pure, or almost pure, or in some certain state, and that they cannot derive this quality from any thing but the principle of taste, which is fire. We may easily perceive that with so fertile principles, there cannot be any difficulty in explaining every thing.

But this theory of *Lemeri* renewed by M. *Meyer*, although well unfolded, extended and supported by *Meyer* and many other chemists, seemed to be destined to enjoy only a transient reign. For in the very time when M. *Meyer* was giving to his theory its greatest lustre, Dr. *Black*, a Scotch Physician, established one of these

hese capital discoveries which make an era in the history of scien-
es, and which entirely contradicted the doctrine of the chemist of
)snabruck. It is also very remarkable, that it was in making experi-
nents upon the same substances, quicklime and alkalies, that these
wo chemists have drawn consequences quite opposite. So true it
, that in experimental philosophy, we cannot be too attentive in
xamining every circumstance that occurs in our experiments, and
hat we cannot be too guarded in drawing conclusions in order to
stablish general propositions.

Quicklime and alkalies having the property of receiving a con-
derable augmentation and diminution in their causticity, of
ansmitting this quality to, and of taking it from each other, were
he true matters on which it was necessary to make experiments, in
rder to acquire new knowledge on causticity in general. Messrs.
Aeyer and *Black* have both perceived this, and were accordingly
etermined to make these substances the subjects of their experi-
nents. We have already mentioned the result of M. *Meyer*'s trials.
Ve now proceed to those of Dr. *Black*.

The researches of Dr. *Black* were accompanied with the disco-
ery, that calcareous earths and stones are in their native state,
aturated with water, and with a large quantity of a volatile and
lastic substance; that the effect of the calcination of these stones,
vas to deprive them of their water and volatile substance, which
vas at first called *fixed air*; that calcareous stones acquired as
nuch more causticity, and the other qualities of quick-lime, as
hey were more perfectly deprived of this volatile substance. Dr.
Black's experiments prove moreover, that alkalies fixed or volatile,
efore they have been altered by fire, or by quick-lime, are in a
reat measure saturated with this same volatile matter or gas; that
his saturation renders them capable of crystallization, and consi-
derably diminishes the causticity of which they are susceptible;
hat if these alkalies be mixed in a proper proportion with quick-
ime, this latter substance deprives them of their gas, and is there-
by saturated, by which means the quick-lime, which owes all its
causticity to its having been deprived by calcination of this gas,
now resumes all its former mildness, and the other properties which
t possessed before calcination; and that at the same time the fixed
or volatile alkalies being now deprived of this matter by quick-
lime, acquire the highest degree of causticity, and of deliquescence,
of which they are susceptible.

The singular substance which bears so great a part in the cau-
sticity of quick-lime and of alkalies, becomes very sensible, not
only in all the experiments which we have mentioned; but it be-
comes more palpable and even visible, when it is made to pass
from one compound to another. If lime-stone be calcined in close
vessels, as has been done by *Hales*, *Black*, *Jacquin*, the Duke of
Rochefoucault

Rochefoucault and others, the gas or volatile subſtance which is ſeparated by the fire, may be collected into receivers. When matters that contain much of this gas, as uncalcined calcareous earths, and mild alkalies, are diſſolved by any acid, the gas becomes very ſenſible by the conſiderable ebullition and tumultuous effervefcence which it excites, while it is diſengaged from theſe ſubſtances. It may be collected and retained in a bottle, and ſubjected to experiments as Dr. *Prieſtley* has done, and may be ſeen at the article *gas*. The impoſſibility of collecting and of including a ſubſtance thus in a veſſel, is certainly not a ſufficient reaſon for denying its exiſtence, or calling it into doubt, when there are other demonſtrative proofs of it, as ſome perſons who pretend to reaſon upon the ſublimer parts of chemiſtry have done, with regard to the exiſtence of *Stahl*'s phlogiſton, which they have lately treated as an imaginary being, becauſe it cannot be collected and rendered ſenſible. This argument cannot, however, be employed againſt the gas, which we treat of, ſince it may be included without mixture in a bottle.

On the other ſide, it is no leſs demonſtrated by facts, that quicklime and alkalies poſſeſs all their cauſticity when they are deprived of this gas, and they loſe their cauſticity when they are ſaturated with it. This diſcovery, one of the moſt important that has been made ſince chemiſtry has been cultivated, has, as may be well ſuppoſed, entirely put to flight the *igneous particles*, the *cauſticum*, and the *pure*, or *almoſt pure fire*. Accordingly, it has given high offence to all thoſe chemiſts to whom the matter of fire furniſhed ſo convenient an explanation of the phenomena of cauſticity.

Some perſons, in eluding this thorny queſtion concerning the cauſe of cauſticity, diſpute about the name *fixed air*, which has indeed very improperly been uſed, after *Hales*, to denote the gas of which we are treating, and which has been applied alſo to other gaſes of a different nature. They have drawn advantage from this confuſion of names to attack this great diſcovery, in repreſenting it as nothing more than what *Hales* had before ſhewn, although in fact it is very different, eſpecially in this reſpect, that *Hales* made no application of his experiments towards explaining the cauſe of cauſticity. Others, who eſpouſe the doctrine of fire being the cauſe of cauſticity, have denied or conteſted many of the facts on which the theory of Dr. *Black* is founded. Moſt of thoſe who have taken the pains to verify or extend theſe experiments, have given ſolid anſwers to every objection, and have added the confirmation of ſeveral new experiments. Amongſt theſe, M. *Lavoiſier*, one of the chemiſts of the academy of ſciences, has performed this taſk with great ſucceſs. This philoſopher, by means of weight and meaſure, has added the ſeal of authenticity to theſe facts, while he

ie verified them with great accuracy, in presence of commissaries named by the academy for this purpose.

It is then well demonstrated, that the caustic, or mild state of calcareous earths, and of alkalies, is not owing to the presence or absence of *igneous particles*, of *causticum*, or of *almost pure fire*, but to the separation or union of a volatile substance or gas, and water, which put them into a state of saturation, more or less complete, according to the general rule of all the other operations in chemistry. What can then be opposed to this demonstration, by those chemists who can conceive no other cause of causticity, but the action of igneous particles? Will they say that the gas itself is nothing but air and fire? This answer would be good, if calcareous earths and alkalies became so much more caustic, as they contained more gas. It would also be well to prove that this gas, which is known to extinguish fire, contains really more fire than other bodies. But the contrary happens to be the truth, as we have shewn; and accordingly, this supposition would sooner prove, that fire is not the immediate cause of causticity; for if it were, the consequence would be, that the energy of this quality is diminished in proportion as the cause which produces it is encreased, and that it would be encreased by diminishing its cause; propositions which certainly cannot be maintained. Can it be possible that an attachment to the doctrine of *causticum* and *fire* can be carried so far as to attempt to reconcile this contradiction, by saying, that the *causticum*, or *almost pure fire* of the caustic earths and alkalies is in a certain state, different from another certain state in which it is, when it is contained in the gas? There could not, I confess, any reply be made to such an answer, for the same reason, that it would be useless to reply to the epicycles and crystal-skies imagined by the defenders of *Ptolomy's* system, whenever any new phenomenon was discovered in the course of the stars, contradictory to this system.

After we have mentioned facts which demonstrate so clearly as those above related, that the effect of causticity cannot be attributed to the action of igneous particles more or less combined, or uncombined, it would be superfluous to add weaker proofs, if the subject were not of such importance in chemistry, that nothing relative to it ought to be neglected. I will add then here some considerations which tend to throw light on this matter, and which prove in a general manner, and applicable not only to the causticity of earths and alkalies, but also to the causticity of all other substances, that the cause of causticity, or of the want of this quality, does really depend upon nothing else than the different states of saturation.

The first observation which I shall make, will have for its object the comparison of the properties of the most caustic substances with

with those of fire. I say then, that if the action of caustics were not properly their action, but the action of the fire that is united to them, the greater their causticity, the more analogous ought their properties be to those of fire, since this causticity is not supposed to be owing to any thing, but to a fire more abundant and more uncombined and pure in these caustic bodies, than in others which are not caustic. On the other side, the most characteristic property of uncombined and active fire is that of occasioning the sensation of heat, and the rarefaction of the bodies on which it acts. These positions being established, the *causticum*, or *almost pure fire*, ought to produce these effects of uncombined and active fire in a manner so much more decisive, as the caustics are endowed with a greater causticity; but experience proves completely the contrary. If a thermometer be plunged into a caustic alkali, into the most concentrated vitriolic and nitrous acids, into solutions of silver, of mercury, of butter of antimony, in a word, into the most violent known caustics, no greater degree of rarefaction will appear in the fluid of thermometer than if the instrument had been left in the air, or plunged into water, oil, or other mild liquor. We may then conclude, that the pretended fire of caustic substances is not either more abundant, or more pure, or more uncombined, or more active than that of other bodies.

It is true, that at the time when caustics or chemical solvents act, a degree of heat is frequently excited, which is sometimes considerable, and proceeds even to ignition. Those who acknowledge fire as the cause of causticity, avail themselves much of this phenomenon, in saying, that this heat is a sensible effect of the *causticum*, or *almost pure fire*, which the caustics or solvents contain, which not being able to enter as a component part in the new compound resulting from the solution, is disengaged and escapes, while at the same time it manifests its presence in the most evident manner; and we must confess, that this is one of their most plausible arguments. I nevertheless think that this argument can only satisfy those whose attention is totally absorbed by a particular fact which strikes them, so as to prevent them from perceiving in this phenomenon the effects of a cause much more general.

It is a fact demonstrated by numerous and incontestable experiments, that the collision of hard bodies produces heat, and even ignition. Hence there is no hard body whatever, which is not heated more or less, and even becomes luminous, in proportion to the percussions, collisions, or frictions which it suffers. And this is precisely the case with the solid parts of caustics, or chemical agents, or of the bodies on which they act, and from which they suffer an equal reaction in the time of solution, or in the act of all the combinations that are accompanied with violence and rapidity. The heat therefore that is produced in all

e chemical operations is no more the effect of the portion
lmost pure fire, or causticum, than it is the effect of these
ciples, when two flints are rubbed violently against each other,
which certainly have no property that approaches in any de-
to causticity.

The phlogiston or combined fire, which enters into the combi-
on of so great a number of compounds, may undoubtedly pro-
e, and does really produce a considerable effect in many oper-
ns of this kind, since it is capable of becoming disengaged from
whenever the parts of bodies which contain it, receive a suffi-
t collison to produce ignition, and so that it may be separated
n them by means of air. It then augments the heat and light,
it is from this cause that, the rubbing of two pieces of wood
nst each other, produces not only a burning heat, but even
e and conflagration, while the collision of two flints, excites
a smaller degree of heat, and a weak and transitory light.
we ought to take notice, that this kindling of combined fire
circumstance, which may accompany the effect of causticity,
ough it be entirely distinct, and unconnected with it, as is
nowledged by M. *Meyer* himself, who very carefully distin-
shes his causticum from phlogiston, and also by M. *Beaumé*,
, when he calls his almost pure fire the principle of causticity,
ar from confounding it with phlogiston, since the latter prin-
e is fire, so far from being pure, and is so combined, that the
pounds which contain it most abundantly, as grease, oils,
s, &c. are actually the mildest and least caustic of all substances.
ogiston is not then in any of these cases the first cause of the
produced by the action of caustics or chemical solvents, but
ely a cause concomitant with this heat, an auxiliary cause fit to
ment it, and to render it more durable.

The best method of finding the truth, and of shewing it to others
ifficult matters, where it does not at once appear, is to be candid,
issemble nothing that may be favourable to the opinions con-
ed, to search also carefully all the objections that may be made
nst the opinion that is adopted, and to present them in all their
e. This is also the only method of bringing to light matters
in obscurity, as this is. I will therefore, by no means, omit
tioning the fact which appears to me the most favourable to the
ion that attributes causticity to the matter of fire.

We have said that heat is commonly excited when caustics ex-
se their action, and I have shewn how I conceive that this effect
be explained, without admitting a greater quantity of fire in
stics than in other bodies. But in the detail of these effects, a
umstance occurs which I am the less inclined to omit, because it
le a great impression on myself. It is that the degree of heat
duced when acids combine with alkalies or absorbent earths, is
very

very different according to the ſtate or theſe alkalies, that is, whether they be cauſtic or mild. It is very certain, that the heat produced when an acid acts upon a fixed or volatile alkali that is not cauſtic, or upon uncalcined calcareous earth, is inconſiderable, and that the heat is very ſtrong when the ſame acids act upon cauſtic alkalies, or upon quicklime. I have frequently repeated theſe experiments, and I have with ſurprize remarked this difference. I confeſs that this fact alone appears at firſt a proof that fire was the immediate cauſe of cauſticity, and I was forced to ſay with the partiſans of this opinion, that mild calcareous earth contains no more fire than other bodies, and therefore produces little heat, when it combines with acids; but that by calcination it retains a portion of the fire employed, and that this portion of fire retained, gives to it the properties of quicklime, renders it cauſtic, and in a word is what eſcapes when quicklime is combined with acids, and which produces the violent heat that accompanies this combination. This heat is ſenſible, it burns; how can ſo demonſtrative a proof be reſiſted? The ſame difference of heat having place between mild and cauſtic alkalies, I could ſcarcely avoid falling into the opinion of Meſſrs. *Meyer* and *Beaumé*, that as theſe ſaline ſubſtances acquire their cauſticity from quicklime, they owe it to the *cauſticum* or *fire almoſt pure*, which paſſes from the quicklime into the alkalies; which explanation ſeems to be further confirmed by the mildneſs which the quicklime reſumes, after having thus communicated its cauſticity, or its principle of cauſticity, to alkalies.

Theſe remarkable effects, and the reflexions which they naturally produced, held me, I confeſs, during ſome time, in a ſtate of uncertainty. On one ſide, I was preſſed by a kind of demonſtration founded on an experiment ſo ſenſible; and on the other ſide, I felt the greateſt repugnance to attribute cauſticity to the parts of fire, becauſe this ſyſtem has always appeared to me contrary to the nature of fire, and of all the great phenomena of chemiſtry. The method I took to extricate myſelf from this embarraſſment was, to take care not to confine my attention to one circumſtance of the experiment, but on the contrary, to conſider carefully even its moſt minute details, becauſe a fact really proves nothing but what reſults from every particular accompanying it. But in the fact, which we are now conſidering, there is a circumſtance, which ſeems to give a ſatisfactory ſolution of the difficulty, and this is the efferveſcence which always accompanies the combination of acids with mild alkalies, or uncalcined calcareous earth, and which does not accompany the ſaturation of acids with cauſtic alkalies and earths. We now know that all the efferveſcences which happen in ſolutions and combinations, are owing to a diſengagement and evaporation of a volatile matter or gas, which ſeparates during the act of combination, from one or both of the combining

ſubſtances.

nces. We also know that the evaporation of volatile fluids,
least, of many of these fluids, produces cold, and even a de-
f cold proportionable to their volatility, and facility of eva-
on. This position being established, as a fact, whatever be
use of this effect, it is no less certain, and it is very easy to
ve, that if, as I do not in the least doubt, there is no more
caustic than in mild alkalies and earths, these latter would
ce in their solution by acids, the same degree of heat as the
r, without the circumstance of the evaporation of their gas,
, by occasioning cold, necessarily diminishes the intensity of
eat. Accordingly the caustic alkaline matters, which do not
n any gas, and which dissolve without effervescence, produce
; their solution by the mere motion of their parts, all the heat
they are capable of producing, because there is no cause to
ck that heat; and on the contrary, the same alkaline mat-
when mild, dissolve with much less heat, because the eva-
on of the gas, and its consequent cold, checks considerably
eat, which, without this circumstance, would be as great as
rmer.

these phenomena so interesting, prove the necessity of not
ng, without reflexion, even from the most imposing appear-
Who would not believe, since collisions, in general pro-
eat, that those which are so evident in the solutions of effer-
g substances, should not produce more heat than the perfectly
uil solution of caustic substances? The contrary, however
ns. All these great movements of effervescence are accom-
d with little or no sensible heat, while the burning heat re-
g from the peaceable and silent solution of caustics, cannot
rceived without surprise.

econd consideration which I ought to add here, concerning
city, relates to the impression which the substances called
make on the organ of taste. It appears certain that this
ssion does not differ essentially from causticity; but solely in
egree of its energy; for we see that the most caustic matters
o those which have the strongest taste, and that those which
rfectly free from causticity, are also totally destitute of taste.
icity and taste are then not two different qualities, but one
he same property, more or less strong and decisive in its effects,
ave said in this article, and more fully at the article *salt*.

cording to what we have just said, if all causticity proceeded
igneous particles, it would necessarily follow, that fire is also
nly matter that is essentially sapid; and that all those sub-
es which have taste, must derive this quality also from the
hich they contain. This is a necessary and just consequence
s system. M. *Beaumé* however, is the only person who has
n this consequence, and has declared, that fire is the only

C substance

ſubſtance in nature, which has eſſentially taſte, and is the proximate cauſe of taſte in all other bodies. As the mere impreſſion which pure fire makes on our touch and taſte, is nothing but the heat and the burning, it follows from this ſuppoſition, that the moſt ſimple taſte of all, that which, if we may ſo expreſs it, is the element of all taſte, is nothing but heat or burning, and that when we taſte any thing, our tongue and our palate are really only heated, or in ſome degree burned. The great diverſity of taſtes does not make any difficulty in this ſyſtem, becauſe, while it admits that fire exiſts in compounds in a great variety of different ſtates, as M. *Beaumé* ſays, this great diverſity of taſtes will be eaſily explained by an equal diverſity of ſtates, in which fire may be in the different ſapid bodies.

So far the explanation may be ſuppoſed to proceed well. But the kind of ſenſation that is directly oppoſite to that of heat, that ſenſation which is ſo contrary to that of heat, that they mutually deſtroy each other, and cannot both exiſt in the ſame perſon at the ſame time, I mean the ſenſation of cold; how is it to be explained in this ſyſtem? This difficulty, which has not been foreſeen, appears to me to be very embarraſſing. For if the impreſſion of heat has a right to be conſidered as a ſimple taſte, and principle of all other taſtes, why ſhould not that of cold, which is equally ſimple, and no leſs ſenſible to our organs, have the ſame right? It does not appear that we can alledge any reaſonable motive for refuſing it. When water is heated, it gives to my tongue and palate the ſenſation of heat. I am told that this impreſſion is produced by the particles of fire contained in the water. When I let the water cool, till its temperature be equal to that of the human body, it makes no very ſenſible impreſſion upon my organs. It will then, I ſuppoſe be told me, that water, being naturally as inſipid as every other body, excepting fire, cannot now have any taſte, becauſe it contains no more of the principle of taſte, that is, fire, than other inſipid bodies. So far ſtill the explanation may perhaps ſeem to go on well. But when I let this water cool as much below the human temperature, as it was at firſt heated above it, and taſte it once more, it makes on the organ of my taſte an impreſſion no leſs ſenſible than the firſt, but quite oppoſite. If I aſk the cauſe of this new impreſſion, what anſwer can be given? If it be ſaid that the impreſſion of cold is not a taſte, I ſhall aſk, what right has then the impreſſion of heat to be conſidered as ſuch. And if it be admitted (for it cannot be conteſted) that they have an equal right; I will then ſay, that as cold is only produced by the abſence of fire, the cold ſenſation cannot be the effect of the action of igneous particles, and I ſhall thence conclude, that all taſte cannot depend on the action of thoſe igneous particles.

To

exhaust all the answers that may be imagined to such pressing
lties, will it be pretended, that the sensation of cold, as well
heat, proceeds from the action of fire, by saying that when
hotter than my body is applied to my organs, the igneous
les act upon those organs in passing from the water to my
in order to be equally distributed, or produce an equilibrium
t; and on the contrary, that when I put colder water into
outh than the temperature of my body, some igneous particles
om my body to the water, in order to bring it to an equal
rature; that in this latter case, in which the sensation of cold
luced, as in the former, when the sensation of heat is occa-
, both these sensations equally result from the immediate ac-
the parts of fire upon our organs, with the sole difference
heat, the action of fire irritates the parts of our body in quit-
he hot substance to enter into the parts of the organ of taste;
at in cold it shakes the sensible parts of our body by its
ent, in passing from them to the cold substance. If this
were given, I would reply, that if the above explanation
dmitted, it must necessarily follow, that the impressions of heat
ld, proceeding equally from the action or impulse of the par-
f fire, their difference would depend solely on the difference
ctions with which these particles move; and that this ele-
ust consequently be endowed with the property of produc-
at when it moves in a certain direction, for example, from
o left, and of producing cold when it passes in any other di-
, as from left to right. I shall say no more on this subject,
ave too good an opinion of the understandings of those whose
n I contest, to suppose them incapable of perceiving all the
ity and ridicule of such an answer. For the same reason, I
it needless to talk here of the frigorific fluid of *Muschenbrock*,
rts of which, might be supposed capable of exciting the sen-
of cold, as well as those of fire can excite the sensation of
For if we admit such a fluid, of which however none of the
of heat and cold prove the existence, it would be an absolute
ation of the principle contested, that fire is the sole cause of

m these observations, it appears as clearly demonstrated as any
of Natural Philosophy can be, that the proximate cause of
ity and taste is not the immediate action of the particles of
ire, or almost pure fire, or any causticum. Besides, it is easy
ceive, that if we were to admit the igneous matter or element
as the sole caustic and the principle of causticity and taste in
er bodies, that would not be establishing a general theory of
city, for we should not on that account, have a clearer and
precise idea of causticity, that is, of the state in which matter
eral ought to be, to have the caustic property, or to be en-

 dowed

dowed with a dissolving action; since, when we suppose, that fire is the sole substance susceptible of this disposition, the question would still remain in what this disposition of fire consists; and in Natural Philosophy, we ought not to flatter ourselves that we have gone as far in the discovery of the causes of the great effects of nature as the human mind is capable of, while we may hope to rise higher than that kind of particular causes to which we at first have reached. Thus when we attribute causticity to the immediate action of fire, we do not truly assign the cause of causticity and taste, since the questions still remain why fire has causticity and taste, and of what these qualities consist.

But if it be asked, what then is the true cause of causticity, I might answer plainly that I knew nothing of it, yet the opinion which I have contested, would not on that account be better founded than I have shewn it to be. However, I cannot now make that answer, although perhaps it would be the wisest and the most reasonable. I have explained my sentiments upon this subject in many articles of the first edition of this work. It is necessary then that I should explain them here as clearly as I can. But it will be not improper, before we enter upon this discussion, to make the following preliminary observations.

First of all, I agree, that if disengaged fire be a substance essentially fluid, and the cause of fluidity in all other bodies, as I think; this element must be considered as a remote cause of all causticity, since the effect of the actions of solvents or caustics cannot take place without the fluidity of the caustic, and of the body on which it acts, or at least of one of them. Thus disengaged fire has its influence in the production of causticity; but not as an immediate cause, that is to say, by the direct action of its own parts upon the body which suffers the effect of the caustic, but merely as being able to put the parts of the body in a necessary state of mobility, that causticity should have its effect. Thus the action of disengaged fire is only a conditional cause of causticity, a *causa sine qua non*.

Secondly, I agree that disengaged fire is itself, a violent caustic, in the sense that I shall explain, and that also, from the reasons which I have just assigned, it has influence in producing this effect; that in many circumstances, it may augment the causticity of bodies, as it really does in the case of solvents, whose activity is rendered greater, and in that of aliments, whose taste is rendered stronger, by heat, than when these matters are cold.

Thirdly, It is very essential to recollect here, what I have said at the beginning of this article, on the action of caustics and solvents; that two effects necessarily result from this action, namely, the separation of the parts of the body acted upon, and the union of these parts with those of the caustic or solvent, so that this se-

paration

on and this new union are two simultaneous effects and inse-
le from the same cause. When I say that these two effects
separable, I would not have it understood that the union of
arts of the body dissolved or corroded by the caustic, with
arts of this caustic, is always proportionable to its action, or
that it never fails to happen; for this assertion would be
ary to experience. But I say that the new union is the
of causticity, or of the dissolving power; that it is a
quence, or necessary dependant on this power, and that it
s occurs as completely as circumstances can permit. The
nion is so far the end, and even the sole end or purpose of
on, it is a dependance and consequence so necessary, that
ut it, solution could not take place. The proof of this is,
he action of the solvent, or of the caustic, is absolutely pro-
nable to this union, that is to say, that if, after the caustic
oduced all its effect of solution, its parts are no longer ca-
of contracting any union with those of the dissolved body,
lvent preserves, after this solution, as much causticity or dis-
g power as it had before; that if, on the contrary, an inti-
nd perfect union of the parts of the solvent with those of the
lissolved, has followed the solution, the smallest appearance
sticity, or dissolving action no longer remains with the cau-
solvent; and that lastly, if this consequent union, or ra-
hat which accompanies the solution, is made more or less
etely, the caustic always retains a degree of causticity very
y proportionable, in an inverse ratio, to the intimacy of this
. These are facts established upon as many experimental
as there are operations in chemistry, and which cannot be
ied by any person who is really conversant in that science.
ese positions being established, what other idea can be reason-
ormed of the state of any substance that possesses the quality
causticity, which is demonstrated by facts to be nothing else
tendency to union, than to consider the integrant parts of this
substance as being so disposed, either by their figure, or by
terposition of some other substance, that not being able to
ogether with the intimacy to which they tend, they retain
atisfied force, by means of which they are determined to
with the integrant parts of any other kind of body, with
they may have the liberty of contracting an union more in-
than that which they have between one another?
en I examine a fixed vegetable alkali rendered as caustic as
be, I see that this substance has an extreme activity to cor-
nd dissolve whatever it touches, that its taste is acrid to a
that gives pain; that if it be deprived of water, it seizes
uid with a surprizing force, when mixed with it, or even
it from the air; that its deliquescence is extreme; that it

corrodes and reduces to a paste all vegetable and animal matters to which it is applied; and that it dissolves oils and fat effectually, and converts them into soaps. But what is the result of all these solutions made with such activity? Its dissolving power or causticity is constantly diminished in the same proportion as it is exercised, or rather, as I have said, in proportion to the intimacy and force of the union, which this caustic contracts with the substances on which it exerts its action. If, for instance, it has united with the volatile matter or gas of calcareous earths, as this light and almost aerial substance has too little solidity to contract with it the most intimate union, it preserves still, notwithstanding this union, a portion of its dissolving power, and it retains all the characteristics of a fixed alkali. But also, as it is combined to a degree with this gas, its causticity ought to diminish, and actually does diminish in proportion to this new union. Not only the acrimony of its taste is abated, but also it no longer acts as a cautery to animal flesh. So far from being deliquescent, it is capable of crystallization, and of being preserved, during its exposure to air, in form of dry crystals: It has no longer strength enough to dissolve oils and fat so effectually as is necessary for the combination of soap. The same observation may be extended to its other properties.

If, instead of uniting the alkali with gas, it be made to combine with oils and fat, it exhausts a greater part of its causticity on these matters, because it contracts with them a more intimate union than it does with gas. Accordingly the alkaline properties, and dissolving power, although they be still somewhat sensible in soaps, are nevertheless infinitely less so than in the alkali simply saturated with gas.

With acids in general, but particularly with vitriolic acid, the action of the causticity of alkalies, and its abolition which is the consequence of it, are manifested in a manner still more striking. Let attention be given to what happens to the most caustic fixed alkali, when it can act upon the vitriolic acid, which also is a powerful caustic; the integrant parts of these two corrosives are so disposed, that they can contract with each other an union, much more intimately than with most other substances. Accordingly they unite with great violence, and by this union they reciprocally exhaust their activity, so that after they are united, no causticity remains either with the acid or with the alkali. The new compound resulting from this union, called *vitriolated tartar*, scarcely retains a saline taste, and very little solubility in water. It is now scarcely able to shew marks of its action upon any body.

Lastly, if instead of combining caustic alkali with vitriolic acid, it be made to act upon a matter purely earthy, (which cannot be done without fusion by violent heat, on account of the force of aggregation

egation of the integrant parts of the earth) the action of this tic is exercised so completely upon the earthy matter, and the n which the parts of these two substances contract together, ccount of this action, is so strong, that the new compound, that e glass which is thus made, far from giving the least sign of icity, has not even the slightest taste, nor any saline property.

hough all these facts be so well known to chemists, that they be reckoned trivial, I think it proper to collect them here, ing them together under one point of view, because the efforts have been made to explain causticity by the action of igneous cles, or of a causticum, prove clearly that the natural conse-ces of this *saturation* which accompanies the action of caustics, which is the effect of it, has not been sufficiently understood ttended to. For the same reason, I shall also make some re-ons on several of the circumstances of the combinations of cs with bodies on which they exercise their causticity.

may at once remark, in all the examples which I have ad-, the exact proportion that is maintained between the dimi-n of the causticity of the alkali, and the degree of force with this caustic adheres to the substances to which it unites. Of iese substances, gas is that with which its union is the st and least intimate, since quicklime, and all acids, even the est, can, without the help of heat, deprive it of this gas the greatest ease. Accordingly all the effect of the diminu-f causticity which this gas is capable of producing upon the , even when saturated with it, is only to render it capable ystallization, less deliquescent, less acrid, and less fit to be ined with oils and greasy matters, but the alkali still retains alkaline properties, so that when it is in this state, it is called or *ordinary fixed alkali*.

hough oils and fat do not contract a very intimate union caustic alkali in the composition of soap, since these oils be separated without heat, by the weakest acids, yet this is stronger than that of alkalies with gas. For these oils can-e separated from alkalies by means of quicklime as gas may, the causticity of alkalies is more abated by oils than by gas. universally known that soap is less caustic, less solvent, and lkaline than the alkali that is most saturated with gas, and st crystallizable.

is also a truth acknowledged by all chemists, that any acids act a more compleat and stronger adhesion than oils with c alkali, and we also see that in all salts compounded of acids lkalies, the alkaline causticity is so diminished that it is not nisable, and disappears so much more completely as the united with the alkali is more simple and more powerful.

 I could

I could thus trace the combinations of caustic alkali with a great number of other substances, such as sulphur, metals, arsenic, sedative salt, charcoal, the colouring matter of Prussian blue, &c. and I could shew the same proportion between the diminution of its causticity, and the intimacy of union that it is susceptible of contracting with each of these substances. But that I may not too much lengthen this article, I will confine myself to the union of alkali with purely earthy substances, by means of fusion; and I observe that this union in a perfect vitrification is the strongest of all, since it cannot be destroyed by any known intermediate substance, and since it resists the action of a most violent fire. It is therefore of all the combinations of caustic fixed alkali, that in which its causticity, and its other weaker saline qualities, are most perfectly abolished, and even to such a degree that if we did not know the composition of glass, none of its properties would shew that it contains much alkali *.

What I have said on the causticity of fixed alkali is applicable to that of acids, and in general of all other caustic substances. If I wrote only for readers profound in chemistry, they would themselves make these applications: it would be useless to adduce more examples, and even those which I have mentioned, would have been superfluous. But as the explication of the true cause of causticity, appears to me to be the sole foundation of all rational theory in this extensive science, I cannot forbear clearing up this matter to the understanding, and the conviction of persons of less extensive genius, who may find some difficulty in seizing all the relations, and in comprehending the whole of a grand number of facts.

I shall therefore give an example, which I have chosen, because it contains a particular circumstance, that merits attention.

When good nitrous acid is applied to quicklime, the causticity of the acid is exercised with violence and heat on this earth. When another portion of the same acid is applied with heat to tin, it acts upon the metal with the same violence and heat as upon the quicklime. But when we examine the result of these two mixtures, we find a very striking difference. The mixture of the acid and quicklime has no causticity, taste, or any of the characteristic properties of acids; whereas the mixture of the acid and tin retains on the contrary all the causticity and acidity of the nitrous acid. Whence proceeds so singular a difference. The partisans of *pure fire* or *fire almost pure*, or of the *causticum*, can say nothing, but that, during the action of the acid and quicklime upon each other, the fire of which these two caustics are full, and to which they owe their causticity,

* It is said in a memoir that gained the prize of the academy, that flint-glass retains no alkali. But this is a mistake. *See* VITRIFICATION.

city, ſeparates from them and thereby produces the heat ob-
l, and that in loſing their fire, they alſo loſe their cauſticity.
anſwer is ſufficiently clear; but it will not apply to the cauſ-
which remains with the nitrous acid, after it has acted upon
n. We muſt ſuppoſe that this acid, which loſes its cauſticity
it acts upon quicklime, does not loſe it when it acts upon tin,
ugh the heat and commotion which accompany this action be
ſt as conſiderable as thoſe which ariſe from the action of the
acid upon quicklime. We muſt ſuppoſe that the heat of the
on of tin, is cauſed by the diſengagement of the particles of
hat are combined with the tin, and which fly off from this me-
n preference to the particles of fire combined with the nitrous
but we could aſſign no reaſon for this preference, ſince on the
ary the phlogiſton of metals appears to be more ſtrictly com-
l than in nitrous gas.

t when inſtead of all theſe ſuppoſitions deſtitute of proofs, I
ine the ſtate of the two ſolutions, I ſee that in the ſolution of
klime, this earth has entirely diſappeared; that it has combined
the acid, in ſuch a manner that nothing remains but a tranſ-
nt homogeneous liquor: In a word, I am convinced from the
riment, that the reſult of the action of nitrous acid on quick-
, has been, that all its particles have united to all the parts of
quicklime, and I thence conclude that the tendency of combi-
on which the parts of theſe two ſubſtances had before their
n, in which their cauſticity eſſentially conſiſted, having been
fied by this union, which they have contracted with each
r, their cauſticity ought neceſſarily to be aboliſhed or dimi-
d, in proportion to the intimacy of this union. I then pro-
to the examination of the ſolution of tin, and I find that this
l or its earth, after ſuffering all the corroſive and cauſtic action
e nitrous acid, has been only divided by this action, and has
precipitated in form of a white ſediment; in a word, that
arts have not contracted any union with thoſe of the acid, and
ence conclude, that as the cauſticity of the nitrous acid is no-
g elſe than the tendency which its parts have to union, and as
s exerciſed this tendency upon tin, but not ſatisfied all this
ency by its ſubſequent union with this metal; this acid ought
tain afterwards the ſame cauſticity and acidity as it had be-
; and this is what actually happens in the experiment. I now
which of theſe two explanations is the moſt ſimple, and beſt ac-
s with all the phenomena of ſolutions, combinations, ſatura-
s, that is to ſay, with all the grand effects, the knowledge
hich, and their relations, truly conſtitutes the ſcience of
miſtry.

have purpoſely choſen the example of the action of the nitrous
upon tin, not only to prove, that cauſtics preſerve their cau-
ſticity,

fticity, when, after having exercifed all their force upon a fubftance, they contract no union with this fubftance, but alfo that I might have an opportunity of making fome remarks upon this phenomenon, which is more or lefs evident in almoft all folutions and combinations. In fact, it fcarcely ever happens in any of thefe operations, that, after the folution, the parts of the folvent, and thofe of the body diffolved, are united with all the force which they poffefs.

It is for this reafon that cauftics, after having exercifed their action upon certain bodies with all their activity, preferve ftill more or lefs of their caufticity, of their diffolving power upon other bodies, and of their tafte. Sometimes they retain thefe qualities entire, or almoft entire, as in our example of nitrous acid with tin. There are cafes of this kind ftill more remarkable, namely, thofe in which, notwithftanding a ftrong union of the parts of the folvent, with thofe of the body diffolved, the new compound is found to poffefs a ftronger caufticity or diffolving power, than either of its component parts had before their union. *Sublimate corrofive*, and many other combinations of metals with acids, are examples of this effect, very worthy of attention. But this phenomenon, fo far from furnifhing an objection, as at firft view it feems to do, againft the general rule of the diminution of caufticity, being proportionable to the intimacy of the union of the parts of the cauftic, with thofe of the body on which it acts, is a new proof of the theory of caufticity here delivered, as will be fhewn at the article SUBLIMATE (CORROSIVE), and in feveral places of this work.

But to return to a more fimple cafe, where the cauftic preferves all its caufticity, after its action upon a fubftance, from want of the fubfequent union with the parts of this fubftance; I mean to the caufticity of *difengaged fire*. I am far from denying that this element is poffeffed of even a great degree of caufticity, when it is not combined; as I have already obferved, it ought to have, and it has, in this refpect, the fame property as any other kind of matter: When its integrant parts are fo difpofed or figured, that they cannot exhauft upon each other, in the ftate of aggregation, their tendency to union, this tendency remains entire, and is confequently capable of being exercifed on any other matter. I do not then fay that fire is not cauftic; but that it does not poffefs caufticity, fo as to exclude all other fubftances from this quality, and that it is not the fole cauftic, or principle of all caufticity and tafte. What I have to remark at prefent, is, that of all cauftics, fire feems to be the one whofe integrant parts, although they may have as much or more tendency to union than thofe of any other fubftance, do however the leaft frequently unite with the parts of thofe bodies on which it exerts its caufticity; fo that notwithftanding

the violent effects of solution and separation, which it produces, causticity remains entire, because it does not continue combined with the bodies on which it acts. The disengaged fire which acted upon most bodies, remains afterwards in the same state the nitrous acid, after it has acted upon tin. It is only in particular cases, that, after it has acted upon bodies as disengaged fire, remains combined with the parts of these bodies, and loses its causticity like all the other caustics, in following the general rule, that is in proportion to the intimacy of the union which it contracts.

I believe I may conclude from these different reflexions and observations, that causticity, the dissolving action, taste, all action, in short, of one matter on another, is nothing but the effect of the general force with which all the parts of matter tend to unite, and apply themselves to each other, with all the intimacy that can be permitted by their bulk, their figure, the vicinity or interposition of molecules of a different kind of substance, and other such circumstances.

That in consequence, every body whose integrant parts are applied to each other with all the force with which they tend in general to union, has no causticity, no taste, no dissolving power.

That the same may be observed of all bodies, whose integrant parts are united to the integrant parts of another body, with all the intimacy possible, that is to say, that the mixt or compound, resulting from this union, has not, while it subsists, either causticity, or taste, or dissolving power.

That every body, whose parts are so disposed towards each other, that the force, with which they in general tend to union, cannot be exhausted by the union which they are capable of having with each other, or with other bodies, has a degree of causticity, taste, and of dissolving power exactly proportionable to the tendency to union that remains not exhausted.

That lastly, a body, whose integrant parts, however small, or near to each other, should be so disposed by any cause, that they could not contract any union or adhesion together, and consequently would possess all their tendency to union; in a word, a substance such as disengaged fire appears to be, would have, for that reason, the greatest degree possible of causticity, of taste, and of dissolving power.

These positions being established, if earth in general, if flints, for instance, have no causticity, no taste, no dissolving power, the sole cause is, that its integrant parts are such that they can closely repose on each other, and adhere together, with all the force with which they tend in general to union. The great hardness, even of the most simple and most homogeneous stones, which are of all the substances known the hardest, is an evident and sensible proof

proof of the extreme force with which their primary integrant p
are ſupported, and applied to each other, and in fact, if we did
admit this force, how would it be poſſible to form to oneſelf, I
not ſay a clear idea of hardneſs, but even any idea of this quality? w
it be ſaid, with the Carteſians, and with *Lemeri*, that the peculiar p
of earths and ſtones are crooked particles inter-twiſted with e
other? But how can we conceive that theſe crooked particles r
their ſeparation, if one does not ſuppoſe, that they themſelves
hard? and would not this be to explain hardneſs by hardneſs,
is, not to explain it at all.

If it were poſſible to ſeparate from each other the primary in
rant parts of the hardeſt flint, and to inſulate them, ſo that t
could not exhauſt upon each other, as in the aggregation of fl
the effort of their particular *gravitation*, or of their tendenc
union, it appears to me evident, that they would be capable t
of exerciſing this force in all its extent upon any other ſubſta
to which they might be applied; that when applied to the tong
they would not only give a ſtrong ſenſation of taſte, but alſo
they would violently cauteriſe the organs of taſte, or any other
of the human body; that they would unite with a ſingular acti
to the particles of air, or of water, in a word, to every ſubſta
which they could touch.

What we have hitherto not been able to do, with reſpect
earth, by any operation of art, nature does daily; at leaſt
certain degree, with reſpect to the earth which ſerves as the b
of marine ſhells. This earth is ſo attenuated and divided by
vital and organic action of theſe animals, that its integrant p
are found to be ſufficiently inſulated, and diſengaged to act u
water and gas, and to unite with them into a compound cal
calcareous earth. The integrant parts of calcareous earth, co
pounded each of earth, gas and water, have a weaker adheſ
together, than the parts of pure and ſimple earth have, beca
the union which the purely earthy parts of the calcareous ea
have contracted with the water and gas, ſaturates to a certain
gree their tendency to combination; but, as it does not entir
exhauſt this tendency, it follows, that calcareous earth ought
have more diſſolving power, more diſpoſition to combine w
other ſubſtances than any other kind of earth that is not ſimila
diſpoſed. Accordingly, experience informs us, that calcareo
ſtones are generally leſs hard than other ſtones, and that th
readily combine, not only with all diſengaged acids, but alſo w
acids already combined with certain baſes, ſuch as the earth
alum, metallic ſubſtances, and perhaps many others.

By the mere effect of heat applied to calcareous earth, its wa
and gas may be ſeparated. It thus may undergo, according to t
degree of heat applied, two changes very different, but very r
markab

kable, and perfectly consistent with the theory that I am en-vouring to explain. If the degree of heat be strong enough, only to separate its water and its gas, but also to bring it into on, then when that heat ceases, its earthy parts approach ards each other, unite into a vitreous aggregation, nearly as ng as that of stones that are not calcareous, and the glass which lts from this fusion, retains none of the properties of calcareous hs, no dissolving power, no disposition to unite with acids, with other substances on which the calcareous earths have a nifest power of acting.

f, on the contrary, the degree of heat applied to calcareous h be such, that it can separate its water and its gas, but too k to make the remaining earthy parts to enter into fusion, then e earthy parts cannot re-unite, because they are not at liberty nove, that is, they have not the fluidity which fusion alone ld give them, and also being deprived of their water and gas which a great part of their tendency to union was exhausted, y remain, merely by being deprived of these two substances, owed with almost all the energy of this tendency, that is to say, austicity, of dissolving power, in a word, of all the properties ch characterise *quicklime*, and of which I shall speak more fully e article *quicklime*.

s to the objection which might be drawn from air and water, ch, although fluid, do not seem to have any causticity, not n the smallest degree of this quality, which is taste, I am con-ced that this objection cannot have the least foundation, but ong those persons who, like the greatest part of mankind, ge without reflexion, and from simple appearances. But a losopher who would give proper attention to the properties of e substances, will be soon convinced that they have, as well ll other fluids, their proper degree of dissolving power and e. Numberless experiments prove that air and water are ong the greatest solvents in nature, though not the strongest; it is therefore not possible but they must have taste propor-able to their dissolving power. It is true, that this taste is sensible; but every one knows that the sensations which the ression of external bodies excites, are relative to the disposi-n of our organs, and that custom particularly prevents our per-ving impressions, which would otherwise appear very strong, perhaps even painful and insupportable. From the first in-nt of our existence, we are constantly exposed to the impression air and of water, which is probably at first, very sensible, as cries of infants beginning to respire seem to indicate. But forget our first sensations, and uninterrupted custom renders at last not sensible of some of them. The taste therefore of air l of water is no longer perceived by us, for the same reason that

that we are not sensible of the pressure of the atomsphere, wh
however is known to be very great.

Besides, although it be true that the aggregation of a substa
is stronger in the state of solidity, than in that of fluidity, and
for this reason, the dissolving power should be more evident
this latter state, than in the former, it does not therefore foll
that liquids or fluids have no aggregation. This aggregation ou
necessarily to subsist always more or less completely, while
integrant parts of the liquid are not sufficiently insulated, and
parated from each other, to be absolutely out of their spher
mutual activity. It is however, only in this latter case that t
parts can enjoy all the causticity or tendency to combination
is proper to them. But we do not know what may then be
causticity of air, and of water, probably it would be less str
than the causticity of earth and of fire. It is however cert
that it would be much stronger than it is in their fluid and liq
aggregation, which is the only state in which the properties
these substances have been hitherto considered. We cannot do
that air and water become powerful agents in a great numbe
chemical and physical operations, as well as fire and earth. Th
considerations offer to chemists a career as new as it is importan
be pursued, and there is reason to hope that some men of ger
may engage in it. The discovery of *gas*, which is very rec
and is, properly speaking, only begun, gives reason to hope
many others may follow. After we have sufficiently ascertai
the existence and properties of the different kinds of gas, we
undoubtedly endeavour to find the nature of these substances
different from all those before considered. And who knows, i
inquiry into the combinations in which air and water ente
component parts, and which are not yet suspected, will not th
the greatest light upon the nature and principles of gases? Am
these substances, there are some which evidently contain an
flammable principle; such are those which are disengaged f
liver of sulphur, and from the solution of several metals by vit
lic and marine acids. But that, which I call *mephytic gas*,
which so far from being inflammable, suddenly extinguishes
flame, when brought into contact with it, and instantly kills
mals, whose properties in other respects partake a good dea
those of water and air, does it not seem to be composed princi
ly of water and air; and is it improbable, that these two prin
ples, which in their state of aggregation, cannot, either of th
combine intimately enough with quicklime and with caustic al
lies to deprive them of their causticity, acquire this property
consequently a solvent power, or a true causticity, when they are
disposed, that their aggregation is much weaker than in their ordi
ry state, and when their integrant parts are not so intimately bo

union, as to check all the tendency to combination, which new mixt possesses, on account of their aggregation being de-ed. We cannot now make any additions on this subject; perhaps the time will come, when we shall be able, by means xperiments to establish a satisfactory theory on this important er.

seems to me that the result of what I have said in this article, at causticity is nothing but the effect of the force with which parts of caustics tend to unite with the parts of other bodies. if most of the chemists who have attempted to give a theory usticity, have been mistaken, as I think I have proved, the rea-s, that they have attended to one part only of the effect of caus-, and have, as I may say, shut their eyes to the most essential mstance; an enormous fault in Natural Philosophy, into h it is surprizing that so many very good chemists should have n. For they, impressed solely with the solution of the parts of s on which caustics or solvents act, and with the tumult, heat, and even inflammation which accompany these solutions rtain circumstances, and seeing on the other side that fire, when gaged and in action, produces constantly these effects, they thence concluded, as the vulgar might, that causticity is only ffect of fire contained in caustics and solvents, without giving east attention to the new union which results from the parts of caustic with those of the body on which it has exercised its n, without considering that causticity always diminishes in ortion to the intimacy of this new union; that the caustic re-s as caustic as ever, if it does not continue united to the body h it has divided, that on the other hand it retains no causticity e combined as strongly as it can be with the parts of the body ved; lastly, without recollecting, that every solvent whose icity has been even the most completely abolished by the union h it has contracted with a body capable of producing this ef-pon it, resumes its causticity entirely, when it is disengaged y means from this union.

m very sensible that this tendency to union which I consider, many Natural Philosophers, as the sole cause of causticity, at the same time of the hardness of bodies, cannot be even rstood by many chemists; and that many artists, although wise very able, will always consider as chimerical a theory attributes to one and the same cause, hardness, insipidity, the ute want of a dissolving power in flints, and the violent caus- of the most active solvents. But in a subject like this, we ot expect that all persons should be unanimous. I therefore n without regret the opinion of those, who not being capable neralizing their ideas, sufficiently to see Nature at large, are r pleased with fancying as many particular causes, as there are phenomena

phenomena to be explained, than to refer to one common and
versal cause an almost infinite number of effects, on account o
considerable difference, even contrarieties, which they think
perceive between many of these effects; who, seeing that fir
very caustic substance, always very active when uncombined
which so easily resumes its activity, rather chuse to consider
element as the sole principle of all causticity, and consequent
the sole active matter that exists in nature, than to acknow
that this same active force is not thus limited and attached to
one kind of matter, but that it is general, universal, common and e
tial to whatever is matter. Lastly, I perceive that some will fi
difficult to understand that this active force is nothing else than
tendency on gravitation which all the parts of matters have to
other, and which is not only the cause of the force with which
parts of the hardest steel adhere to each other, but also o
astonishing activity with which a corrosive acid dissolves and
vours this very hard body.

I foresee all the objections that may be made to such a the
but on the other side, I shall have attained my purposes, and
ficiently explained my opinion; if the philosophers, who are
sible of the simplicity and the general extent of the *Newtonian*
losophy, should think that I have made a rational application
to the chemical phenomena of causticity, of solutions, and of
binations, which, as I have said, constitute properly the who
chemistry.

It is true that the active and general force of matter which *N
ton* denotes by the name of *attraction*, cannot be established in
ticular Physics on proofs of the same sort as those on which
supposition of this force and of its law, is become the most s
factory theory of the movements of the heavenly bodies, an
the system of the world. The sun, the planets and comets,
great masses of matter so few in number, and separated from
other by spaces so considerable, that from the observations of
movements, and by the aid of a profound geometry, it has
possible to discover and demonstrate the perfect corresponden
these effects, with the force which was supposed by *Newton* t
their cause; and this agreement, which is truly admirable,
changed that supposition into a truth almost demonstrated t
persons of good understanding. But particular physics are no
pable of the same advantages. For here an infinite multitud
invisible atoms, inconceivably small, act upon each other at
tances infinitely small and not to be calculated. We cannot h
any idea of their masses, of their velocities, or of their figures,
which, as the Count de *Buffon* has observed, ought necessarii
have influence in their action. The perturbations are innum
ble, and it is consequently almost impossible to demonstrate

m

s of any calculation, the law according to which all these cor-
les act upon each other. But although this knowledge, if it
be acquired, would be a new and very strong proof of the
al action of all the parts of matter upon each other, especially
could demonstrate that the law of their action is the same as
f the heavenly bodies, or is the necessary consequence of it;
ay however, without this knowledge, perceive in general, that
great masses of matter act upon each other at great distances,
nallest particles of the same matter ought also to act upon each
at distances proportionable to their masses, since no reason
xist, why small bodies should be deprived of a property or of
ivity which is so obviously exerted in great bodies.

stly, it appears that this universal tendency of all these parts
tter towards each other is the most simple and general cause to
we can refer the explanation of the phenomena of Che-
y; since no other cause can be assigned, and since the simple
r to those who should ask why matter is endowed with this
force, would be, that as the supreme Being chose that the
should exist as it does, it was necessary that matter should
the properties which it has, and particularly this active force,
ut which the heavenly bodies would not run in orbits round
ter; without which the elements of matter deprived of all
ular movement, would not join nor adhere to each other;
onsequently without which the total mass of matter, supposing
ible that it could in that case exist, would be an immense, and
nless liquid, that is, a true Chaos.

AUSTICUM of M. *Meyer*. This is considered by M. *Meyer*,
nixture resulting from the union of the matter of fire, or of
with a particular and unknown acid. This causticum, which
so calls *acidum pingue*, is according to him the sole caustic and
iple of all causticity. See the articles *acidum pingue*, *causticity*,
lime, and others.

Addition to the Article CLAY *of the former Edition.*

LAY. M. *Beaumé*, who has made many researches into the
nature of clay, the results of which are to be found in a me-
printed separately, and in his chemistry, having carefully
ated most of the experiments already made by the chemists
tioned in the former part of this article, agrees with them upon
most essential point, that is, on the perfect resemblance between
earth of alum when separated from its acid, and the earthy
of clays when purified from all heterogeneous matters, and
icularly from vitriolic acid, a portion of which is found in
or most clays. But this good chemist being desirous to extend
knowledge in this and many other subjects, has conceived some

D peculiar

peculiar ideas concerning the nature of clay, and the cause of
properties of this kind of earth. He considers the argillac
and vitrifiable earths as one and the same species of earth, and
principal fact on which he grounds this opinion is, that vitrif
earth when precipitated from the liquor of flints by an acid, ha
the properties of the earth of alum, and particularly that of form
alum with vitriolic acid. This proves that the argillaceous e
owes its origin to the vitrifiable earth, as *Stahl* has said of th
well as of the calcareous and other earths.

But can it be hence inferred that there is no difference betw
the earth of sand or flints and argillaceous earth, and ough
even to apply to this latter earth, the epithet *vitrifiable?*

By the same rule we might, according to *Stahl*'s idea of calcar
earth, give to this also the name of vitrifiable earth: for it ha
origin and properties common to both, which might authorise
appellation; and on the other side, argillaceous earth has pr
ties very peculiar, by which it is as much distinguished as cal
ous earth is, from vitrifiable. Argillaceous earth has a bin
quality, a peculiar ductility and adhesion to water, w
pure vitrifiable earth never possesses, however finely it ma
divided. It cannot serve as a flux to calcareous earth or gyp
as vitrifiable earth does. It requires even greater heat, a
larger quantity of fluxes than the true vitrifiable earth, to
its vitrification. I know also another very important pro
which I have ascertained by many experiments, by which it d
from vitrifiable earth in a more remarkable degree than in th
stances above-mentioned, even although the latter earth has
fered the greatest division of which it is susceptible, and has
made to approach as near as it possibly can to the argillaceous e
by fusing it with a large quantity of alkali. The property
meant is that by which pure argillaceous earth, or earth of a
when combined with fixed alkali, is the most effectual of all ki
substances in making the red colour of madder adhere to cotto
thread. Vitrifiable earth, combined with fixed alkali, or in
other form, does not possess this property. I shall further obs
that this earth of the liquor of flints, also the earth of the ash
vegetables, and the earth which precipitates spontaneously
fixed alkali, although they be all fit for making alum by combi
with vitriolic acid, are nevertheless very far from the state of
and simple argillaceous earth. They differ singularly from
latter earth, in being exceedingly fusible, which property they
bably owe to a portion of fixed alkali, which is so intim
united with them, that it cannot be washed away by any q
tity of water. All these considerations incline me to think tha
name of *argillaceous earth* ought to be continued, and that of v
fiable earth ought to be confined to the earth usually so called.

fecond opinion peculiar to M. *Beaumé* concerning the nature ays, is, that the vitriolic acid is a neceffary principle of thefe s and one of their conftituent parts. He diftinguifhes in na- clays a very attenuated vitrifiable earth, but which not being bined with vitriolic acid, is not in the ftate of clay, but is only of the materials proper for its formation. Finally, he applies name and properties of clay folely to the combination of this with vitriolic acid. According to this able chemift, this earth he property of combining with this acid in very unequal pro- ons, that is to fay, either in fo fmall a quantity that the falt ing from the combination fhall have a fmall excefs of acid, in h cafe this falt is *alum*, or that a compleat faturation fhould take or even more, and then a vitriolic falt will be formed with an y bafis, which approaches to a felenites with a bafis of calca- earth, by its infipidity and little folubility, but which having ts bafis a vitrifiable earth ought to be diftinguifhed from the by the name of *felenites with bafis of vitrifiable earth*; fo that clay is nothing but alum faturated or fuperfaturated with its , in a word, a felenites with bafis of vitrifiable earth.

ne proofs on which M. *Baumé* eftablifhes this opinion, are, hat he has been able to reduce alum to a kind of felenites by bining in this falt the greateft poffible quantity of its own earth. hat by boiling clays in diftilled water, he has always remarked this water diffolved a falt with earthy bafis, of the fame nature um faturated with its earth, which falt was decompofed by ad- fixed alkali, and the precipitate thereby formed was fimilar to of alum. 3. Laftly, M. *Beaumé* having obferved that all decompofe nitre, that this property is retained even by thofe which have been expofed to violent fire, fuch as that which s into the compofition of India porcelain; and alfo that vitri- d tartar may be obtained from the refiduum of the decompo- of nitre by clays crude or baked, concludes, that vitriolic acid e of the conftituent parts of clay.

appears in fact, that in moft native clays, there is a certain tity of vitriolic acid intimately combined with it and in fome fure fuperfaturated with earth, and this acid adheres ftrongly hefe earths. But is this obfervation fufficient to eftablifh folidly general theory, which we have mentioned, concerning the con- ent parts of clay. I cannot be convinced of it, notwithftand- all the deference which I am difpofed to have for M. *Beaumé*'s ions: Firft, becaufe it has not been proved, that *all* clays do ain vitriolic acid, fince for this purpofe it would be neceffary ave examined them all, which has not been done, nor is poffi- to be done on account of the infinite variety of thefe earths. even probable that clays might be found entirely free from vi- ic acid, as the great quantity of this acid was obferved to vary

much in the clays examined by M. *Beaumé*. If Nature has d
tributed this acid so unequally, is it not possible that to some she m
have given none? Secondly, if the vitriolic acid were an essen
constituent part of clays, they ought to change their nature m
and more as they are deprived of more of this principle; and last
should cease to be clays, when they have been entirely deprived
it. This however does not happen. For clays exhausted by
many washings in ever so much pure water of every thing saline
selenitic, so far from losing any of the argillaceous properties, p
serve them all, and on the contrary, become more binding a
more pure; and on the other side, by adding the proper quant
of vitriolic acid to the earth of alum, this earth ought to be rende
perfectly similar to native clays, but this too does not happen. I
the earth of alum, deprived of all acid, possesses all the argillace
properties in the highest degree, but it loses these properties in p
portion as it is recombined with vitriolic acid; it especially lo
the characteristic property of clay, and by which it is distinguish
from the earth called vitrifiable, namely its peculiar ductility,
M. *Beaumé* himself proves from his own experiments.

Lastly, the decomposition of nitre by clays, and the vitriola
tartar which may be obtained from the residuum of this decom
sition, would prove the presence of vitriolic acid in clays, if t
were the only earth capable of effecting this decomposition, and
the quantity of vitriolated tartar remaining in the residuum w
proportionable to that of the nitre and clay employed. But M.
Veillard found from very exact experiments, related in a Mem
presented to the Academy of Sciences, that the purest sand procu
the decomposition of nitre, as well as clays, and that no vitriola
tartar results from this decomposition. It is not therefore surprisi
that bruised Indian porcelain, mixed and distilled with nitre, sho
occasion the decomposition of this salt. And although the vitrio
acid, which is found in many clays, must undoubtedly contribu
considerably to the decomposition of nitre when such clays are e
ployed, it does not thence follow that this acid should be one of t
constituent parts of clay in general.

All these considerations incline me to believe that vitriolic a
not only is not a constituent part of clay, but also that the a
which is found in many of these earths, however it may be combine
is only accidental; that it is a heterogeneous matter, as foreign
clay properly so called, as calcareous earth, gypsum, spar, quar
sand, bituminous, sulphureous and metallic matters, or any oth
substances that are mixed naturally in a greater or less quantity
almost all clays, and which nobody has ever thought of consideri
as constituent parts of pure and simple clay.

M. *Beaumé*, while he thus extended his researches on clay
could not fail of forming a theory on the cause of the great fusib

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erved in the mixtures of these earths with calcareous earths, gypsums and selenites; a singular phenomenon which Mr. t discovered, and which M. *Beaumé* and I have had occasion ve upon many different occasions in a very numerous course riments which we made concerning mixtures for making n. I had begun these experiments singly, for which I had ted the muffle-furnace capable of producing the most violent which I have given a description in my memoir on clays, he memoirs of the Academy for the year 1758. M. *Beaumé*, nerit I knew, having signified his wish to partake of this ccepted his offer gratefully. The course of experiments had undertaken, was continued with renewed zeal during years, in my laboratory and at my expence. We repeated ll the experiments of Mr. *Pott's Lithogeognosia*, and many M. *Beaumé* has also since that time made many interesting ents on clays, an account of which he has published in his upon these earths, and in his book on Chemistry. All periments serve as a basis to the explanation which he has the fusibility of mixtures of argillaceous and calcareous M. *Beaumé* attributes this fusibility to three causes, 1. to olic acid which he believes to be a principle of clays. 2. to l alkali, which according to his opinion, is produced by the f fire in calcareous earths; and 3. to a principle of fusibility, ature is not well known.

idea not being proposed as a doctrine that is proved, I shall discuss the reasons for and against. I shall only say that li which is supposed to be formed in calcareous earth, and vitriolic acid of clays or of gypsum, do not seem to be pro- rocure, at least jointly, the fusibility, because these two cannot fail in combining together and forming vitriolated which is not a vitrescent salt. I refer to my Memoir on r what I have said on this subject.

result of the experiments which are related in that Memoir thers which I have made since, is that the argillaceous earth , when perfectly deprived of vitriolic acid, is as refractory vitrifiable earth, and even resists more than this latter earth on of saline and metallic fluxes; that the mixture of vitrifi- l argillaceous earths is not more fusible than they are se- ; that pure calcareous earths and gypsums, although very to melt, are nevertheless more fusible, without addition or , than argillaceous and vitrifiable earths; that gypsum is a ore fusible than calcareous earth; that the mixture of a little th calcareous earth or with gypsum, disposes them a little fusion; that pure argillaceous earth in whatever proportion ixed with calcareous earth or with gypsum, does not en- their fusibility; but that by mixing together these three

 kinds

kinds of earths, namely the argillaceous, vitrifiable and the calc
ous, which do not melt singly nor any two of them united,
greatest degree of fusibility is acquired, of which remarkable phe
menon I do not attempt to assign any cause; but it seems to fur
me with an additional argument for not confounding pure arg
ceous earth with that which is commonly called *vitrifiable*.

Addition to the article COMBUSTION *of the former Editio*

COMBUSTION. It is a curious and important question
the contact of air is necessary to combustion. But from
of a sufficient number of facts, this is one of those points in N
ral Philosophy, on which we can only form conjectures. As
then only I propose the following ideas.

It is known that if any combustible body be burnt under a
ceiver containing a certain quantity of air, which cannot be ren
ed, this body burns at first as if it were placed in open air.
that presently its flame becomes smaller and less luminous; th
length, sooner or later, according to the size of the receiver,
combustion ceases entirely.

If we afterwards examine the state of the receiver, we shall
that the quantity of air which it contained before combustion
been remarkably diminished by this operation, so that the rece
is in this respect in the same state, as if a part of the air had
exhausted. This first fact proves either that a part of air is des
ed by combustion, or combines with some of the principles of
combustible body. But if we examine further the air in whi
body has burnt and has become extinct, we find that not onl
quantity is diminished, but also that its nature is changed
many respects, and particularly in this, that it cannot again f
for combustion, even when it is condensed in a smaller receiver;
from this second fact it follows, that combustion does either m
some substance combine with air, which changes the properti
this fluid, or that atmospherical air is a mixture of several
stances, of which only one is fit to maintain combustion, and
this one is absorbed or destroyed in this operation.

These facts are not sufficient to enable us to decide what ch
happens to the air in combustion, and we must therefore rec
analogy. In considering combustible bodies as compound
which the matter of fire is one of the constituent parts, and
combustion as a decomposition in which this igneous princip
separated, it is natural to compare combustion with other dec
positions, with which Chemistry has made us acquainted. But
certain that heat alone is capable of separating the principle
many mixts; and there are others, on which heat is not capab
producing this effect, and which never would have been dec

po

l, if we had not difcovered that the action of certain fubftances
able of effecting or rather compleating what heat alone could
. Several neutral falts, and efpecially common falt, cannot
compofed by the fole action of heat, and we fhould not have
n either the acid or the alkali of this falt, if we had not dif-
ed by experience, that the vitriolic and nitrous acid were ca-
of feparating thefe two conftituent parts, by uniting with one
m, and thereby difengaging the other.

efe things being confidered, may we not conjecture that com-
le bodies are of the number of thofe mixts whofe principles
t be feparated by heat alone, and that the matter of fire par-
ly, which is the caufe of their inflammability, adheres fo
ly to them, that it cannot be feparated without the affiftance
ntermediate fubftance, the action of which united with heat,
es capable of procuring that feparation; and in this cafe, is
probable, that the air is merely the intermediate fubftance
ed, and as fuch is neceffary to promote combuftion? This
ation at leaft appears to agree well enough with all the known
mena of combuftion, and efpecially with the principal and
nental fact, namely, that no combuftible body can really
that is, be decompofed by the feparation of its inflammable
ple in very clofe veffels and without the immediate contact
and that the more confiderable and intimate this contact is,
ore quickly and vigoroufly the combuftion is effected, as ex-
ce fhews.

the fecond place, we may eafily conceive that if air acts in
ftion, as a decompofing intermediate fubftance, it muft fub-
itfelf in the place of the matter of fire, which is thereby dif-
ed from its combination; and it is for this reafon that there
is a confiderable abforption, or diminution in a given quan-
f air that has ferved for combuftion.

why after a body has burnt a certain time, and has fponta-
y become extinct in a quantity of air not renewed, does there
a confiderable quantity of an aerial fubftance which cannot
gain for combuftion? The anfwer to this queftion is, that
ureft air is the only intermediate fubftance which can ferve
mbuftion, and that the air of the atmofphere is a mixture of
ir and of another fubftance, which, notwithftanding it has
pearances and fome other properties of air, is neverthelefs
different. This fubftance is the gas which has been common-
led *fixed air*. But in combuftion, it is only the part of the
pherical fluid which is pure air that is abforbed and combi-
as the decompofing intermediate fubftance; and therefore,
her part, or gas, which cannot act as an intermediate fub-
, remains entire after the combuftion. If this be the cafe,
a body is burnt in air perfectly pure, no gas ought to remain

 after

after the combustion, and I believe this would accordingly happe
but we cannot speak with certainty on this point till many impo
tant experiments have been made, which have not yet been a
tempted, because no method was known till lately of having
much purer than that of the atmosphere, and because the idea
these experiments could not be suggested before the late discover
on the different kinds of gas. Of these I shall relate one of t
finest which I have seen exhibited by M. *Lavoisier*, after I
Priestley, in presence of several very intelligent persons.†

It appeared from the experiments of Messrs. *Hales*, *Priest*
Lavoisier; and *Bayen*, that *metallic calxes* contain a great deal of
aerial substance, which is disengaged during their reduction t
metallic state, and that this substance is the mephytic gas, in
pable of supporting the life of animals, or combustion, when
reduction was effected by means of inflammable matter: But m
cury calcined without addition, called *precipitate per se*, and e
minium and *red precipitate*, being capable of resuming their meta
form without addition, and as this reduction does nevertheless y
a large quantity of aerial matter, it was very important to find
what this aerial matter was, and especially whether it differed f
the gas which is disengaged in reductions of calxes made by me
of combustible bodies, and this was the object of M. *Lavoisi*
experiment, which proved that the aerial substance disengaged f
calcined mercury, when it resumes its form of running mercu
without the addition of any phlogistic matter, not only is not
phytic gas, but is even the purest air that can be found, an
particularly free from any mixture of mephytic gas. But in o
to ascertain this latter fact, it would be necessary to carry the
periment further, by making an inflammable body burn in
pure air separated from calcined mercury, till this body beco
extinct. It would certainly burn much longer than in an e
bulk of atmospherical air; but if this combustion had absorbed
whole of the air, and if none of this gas remained or but very
tle of it, this would throw a great probability on the opinion w
I have proposed. It would then remain to discover what is
part of the atmospherical air, or this gas which cannot serve
combustion.

Dr. *Priestley* who has made us acquainted with many of its
perties by very ingenious and accurate experiments, seems incl
to consider it as a compound of pure air and phlogiston. But
opinion is subject to great difficulties and cannot be confirme
refuted but by new experiments which remain to be made.

We will here recapitulate the manner in which I conceive
combustion is executed.

† The Duke *de la Rochefoucault*, M. *Trudaine*, M. *de Morveau*, the Du
Ayens, and the Duke *de Chaulnes*.

I consider every combustible body as a compound in which ... or the material substance of fire, is combined as one of the ...iples or constituent parts of this compound.

I suppose, from facts, that this matter of light, this principle ...mbustibility of combustible bodies, cannot be disengaged by ...ere force of heat, and without the concurrence of the action ...ecomposing intermediate substance.

I again suppose, from facts also, that there is in nature only ...kind of matter, which can serve as an intermediate substance ...he disengaging of the light combined in combustible bodies, ...hat this only matter is pure air.

... admitting these suppositions which appear to me perfectly ...stent with all the phenomena of combustion, I believe that we ...easily conceive:

... Why any combustible body cannot burn without access of ... and the easier this access is, the more vivid and rapid is the ...ustion.

... Why a given quantity of air can only serve for the com...on of a given quantity of combustible matter.

... Why in all combustions, some air is absorbed and disap..., in a quantity proportionable to that of the combustible ... which burns.

... Why, when the combustion is excited in close vessels, by means ...e included atmospherical fluid, there remains after the body has ...d to burn, for want of a renewal of fresh air, a considerable ...tity of a fluid having the appearance, the transparency, the ...city of air, and which is yet not air, at least not pure air, but a ...which kills animals; which precipitates the quicklime of lime...r, into a mild effervescent calcareous earth, which saturates ...ic alkalies, and renders them crystallisable and effervescent, &c.

... Why the ashes and the alkalies which remain after a simple ...bustion are very effervescent with acids, and yield much gas, ...*ales* has shewn.

... Why the calxes of metals are of greater absolute weight, ... the metal was before its combustion; and why in the reduc... of these metallic calxes, by which they are deprived of this ...ss of weight, there is a quantity disengaged either of very ... air, or air rendered impure, which has acquired the qualities ...ephytic gas, according as this reduction is made, either with ...ithout addition of a new quantity of inflammable matter.

... Lastly, why metals, which after having suffered the action ...cids, are in a state similar to those which have been calcined ...ere combustion, present the same phenomena in their reduc...; and particularly why mercury dissolved and calcined by ...ous acid, when it is again reduced into fluid quicksilver in close ...els, yields a great quantity of very pure air, while the last

portions,

portions of nitrous acid that are obtained by distillation in the pneumato-chemical apparatus, is so altered, that it is only a gas which cannot resume the properties of nitrous acid, till it be recombined with pure air, with a given quantity of which, it unites to the point of saturation.

However important this theory of combustion may be, I should lengthen too much this article by the explanations of these questions. They will occur to the reader after he has attentively examined the articles *Calcination*, *Metallic Calxes*, *Fire*, *Phlogiston* and *Gas*.

Addition to the Article DETONATION *of the former Edition.*

DETONATION. *Stahl* does not only attribute the detonation of nitre to the water contained in it, but he goes farther, and is of opinion that the aggregation of the water is thus entirely broken, and that its particles acquire the properties of air. This is one of these ideas, the impossibility of which is not demonstrated. But it appears more probable, that air is itself one of the principles of the nitrous acid; and if this be the case, it is much easier to conceive why this acid has less occasion than any other combustible body, of the access of air to effect its combustion; since it contains a matter which is gradually disengaged from it while it burns, which has the property of maintaining combustion. The flame of nitre which is made to detonate slowly for the sake of observing it, seems to prove what we have advanced. For it has the appearance of a body, whose combustion is excited by a violent blast, which seems to issue from within itself.

Since the properties of gases have been observed, several philosophers have thought that the violence of the explosion of gunpowder might be produced, neither by the expansion of air, nor of the watery principle of the nitrous acid, reduced into vapours during the inflammation and decomposition of this acid, but to the disengagement of a considerable quantity of a gas which is produced by the effect of the reciprocal decomposition of the nitrous acid, and inflammable matters with which it detonates. This is the opinion of the author of the notes of the *English* edition of the Dictionary of Chemistry; and certainly this opinion is not without probability. It is further shewn by the experiments of Messrs. *Priestley* and *Lavoisier*, and others who have lately attended to this subject, that the nitrous acid is filled with elastic aerial fluids, one part of which may be separated in form of pure air, and the other in the state of a gas, which has no resemblance to nitrous acid; but which has the remarkable property of being converted into nitrous acid, by mixture with pure air. These

phenomena

enomena which begin to throw much light on the nature of the rous acid, and perhaps of other acids, seem to prove that air one of the constituent parts of the nitrous acid, and it must confessed, that all the other properties of this acid are conmable to this proposition. *See* GAS.

FECULES *of* PLANTS. The name of fecule may be given erally to all matters separated or deposited from the expressed ces of plants, or from the water in which plants are infused. e fecules are hitherto but little known, and it is only very latehat they have been examined. All *flours* and *starches* may considered as fecules. At the article *farina*, an account is given he researches made on that subject.

The green part of almost all plants forms another kind of fecule. is found commonly divided and distributed in the expressed ces of plants, renders them green and turbid till they have been ified; which shews that it is not dissolved, but only suspended, accordingly it is easily separated by clarification, deposition, or filtration. This green part of most plants, although it may be arated in form of a fecule, like starches, does nevertheless er essentially from these, in this respect, that it is perfectly inble in water, even with a boiling heat. It appears from a e printed by M. *Rouelle* in the *Journal de Medecine*, (*March*, 3.) that his late brother was the first who began to examine green matter almost universally diffused through the whole veble kingdom. The property which it has of being insoluble vater, and of being soluble in spirit of wine, ether, or oils, had le the late M. *Rouelle* conclude, that it was of a resinous na-e, and this conclusion is in some measure just. But M. *Rouelle*, younger has discovered, that the whole of the green fecule, ch is separated from plants, is not a pure resin, but that it tains another matter very different, as it yields by distillation retort, the same principles as animal substances do, namely, atile alkali and fetid oil, which principles are not obtained from proper resin.

This substance of the green fecules, which is in some measure nimal nature, not being soluble in water, even with the assiste of heat, appears to be very similar to the glutinous part of na. This is the opinion of M. *Rouelle*, and is very probable. is discovery deserves to be prosecuted, and without doubt, it l with all the requisite care, as it cannot be in better hands n in those of M. *Rouelle*.

The green colour of plants is easily altered, and is changed to a lowish brown, by a kind of fermentation which happens to nts, after they have been gathered, unless this fermentation be vented by a quick drying. I shall observe upon this subject, t although this green colour changes and even entirely disap-pears,

pears, it is neverthelefs not deftroyed; and one may, by mean
of menftruums, feparate and extract the green part of dried plant
which have not the leaft appearance left of their green colou
At leaft, when I examined feveral kinds of tobacco with Meffr
Cadet, *Demoret*, and *Mitouard*, it happened, that upon applyin
ether to fome tobacco, which we had exhaufted as much as w
could by means of water, and which had the ufual yellow-brow
colour, a very fine green tincture was thereby extracted.

It is probable, that there is in the vegetable kingdom, and eve
in the animal kingdom, other kinds of feculent matters; perha
even there may be many fuch. It would be an interefting fubje
for examination. Moft of the colouring parts of the dying m
terials, may be nothing but fecules. Thus, for inftance, indigo i
a blue fecule. It differs however from the green fecules of plant
not only in its colour, but alfo in being infoluble by fpirituous an
oily folvents, and in being only foluble by faline fubftances, o
by a kind of putrid fermentation. We may eafily perceive th
this is a new fubject of refearches. Every vegetable or animal
whole in the order of beings; but this whole is an admirable a
femblage of a great many mixts, very heterogeneous, and of di
ferent orders. To feparate thefe from each other, and to difcov
the nature and properties of each, is the object of chemiftry.

FARINA, or FLOUR, is a fubftance which has much of th
nature of gum or mucilage, but which has evidently more taf
is more fufceptible of fermentation, and of yielding nourifhment.

This matter abounds in the vegetable kingdom, and is the
diftributed in different parts of certain vegetables, Some kin
of roots, fuch as thofe of briony, potatoes, that from which caffa
is extracted, falep, and feveral others contain a great deal of
white fecule, which has the properties of farina. But the larg
quantity of this matter fo valuable, on account of its fupplying th
principal nourifhment to mankind, and to many other animal
refides in grains, which are therefore called farinaceous, fuch
thofe of wheat, rye, barley, oats, rice, and other fimilar plant
It is depofited in thefe grains for the fame purpofe, as mucila
and fweet oil are in the feeds called *emulfive*, that is, to ferve fo
the nourifhment and growth of the germ of the plant, in the fir
period of its expanding. It is a nourifhment ready prepared, and a
it be may faid, already digefted by the parent plant, for the fuppo
of the beings which it re-produces. It is the aliment of thei
earlieft age, while they are yet too weak to extract directly fro
the earth and other elements, the materials which they muft a
terwards transform by their organic action into their own fub
ftance; in the fame manner as the emulfive milky matter of man
other feeds, that of the yoke of an egg, and laftly, the milk o
animals, are evidently deftined to procure to the embryos, o
youn

ng of these several beings, a nourishment already half assimila- , the digestion of which is easy and proportionable to the kness of their organs.

As soon as granivorous animals arrive at an age, when they are to go in quest of food, they search for by instinct the farina- us grains, which they prefer to every other vegetable aliments. n man, although he can be nourished by almost all vegetables animals, has discovered from time immemorial, in these grains liment suited to his nature, and preferable to many others. haps he began by bruising these grains between his teeth, and sing those only which grew spontaneously on the surface of earth. But the intellectual faculties which distinguish him other animals, must soon have taught him to multiply this ious aliment, by cultivation, to break the farinaceous grains ween stones, in order to separate from it the farina or flour, lastly to give to this nutritive part certain preparations which er it more palatable, and more easily digestible. This is cer- , that from the earliest ages of the world, men have cultivated farinaceous plants and have prepared the flour which they ce extracted for their principal aliment.

ut it must appear surprising, that it is only within a few years the nature and principles of a substance so useful to us have investigated. Mr. *Beccari* in *Italy*, and Mr. *Kessel Meyer* in *many* appear to have been the first who have made experiments, rder to discover the constituent parts of flour. Their labours not been unsuccessful. To them we owe the discovery of a tance before unknown, whose properties are very curious, idered in a chemical light, and very interesting by the influ- which they must have on the qualities of bread. Another ntage also very great of these first researches, is, that they excited the attention of several excellent chemists, who, after ating the experiments of Messrs. *Beccari* and *Kessel Meyer*, have ed them, and will undoubtedly yet carry them farther.

our diluted and diffused, in cold water, renders this liquid e and milky, without being really dissolved in it. If a cer- degree of heat be given to this water, then the flour is actually lved in it: the opake whitness disappears, and the liquor be- es a transparent paste, and approaching at once to the nature mucilage and a jelly so much thicker, as the quantity of flour loyed has been greater. This kind of paste may be dried by orating the water, and thus becomes a semi-transparent mat- brittle when it is thin, but which has nearly the consistence of gum when it is in thicker masses. This dried paste may be ned, diluted, and even re-dissolved in water as gums are, but a little more difficulty and less completely.

When

When the solution, or even the mere dilution of flour in water, is not quickly dried, a fermentation evidently appears to take place in it, which is at first of the spirituous kind, if the viscidity of the farina has been destroyed previously by the preparation, which farinaceous grains are made to undergo, before they are employed in the making of beer. But this spirituous fermentation is inconsiderable, and passes at once to the acid fermentation, and from thence to mouldiness, to a kind of putridity, if the farinaceous matter has all its viscidity, as we see for instance in paste, which soon suffers these alterations when a quick drying, or great cold do not preserve them.

When flour is diluted with a much smaller quantity of water, it forms a ductile paste, which may be kneaded: And when it is exposed to a baking heat, it forms what is called a cake. By means of this preparation, the flour acquires a more agreeable taste, especially in the crust of the cake, because this crust is dryed by the fire, and even scorched, by which its taste is considerably heightened. As to the internal part or crum of this cake, it is observed to be smooth, compact, more transparent than the paste was before it was baked; in a word, it is a very thick flour-paste, very heavy, insipid, not easily diluted by the spittle, nor digested by the stomach.

But when the paste, before it is baked, is allowed to undergo to a certain degree the spirituoso-acid fermentation, of which it is susceptible, or which may be hastened by mixing with it some leaven, then the paste swells by the disengaging of the volatile gas, which rises in the fermentation, the viscidity is diminished, by the intestine motion and consequent division of the particles. When the paste, as soon as it comes to this state, is baked, it becomes bread, the crum of which, instead of being compact, heavy, and insipid, like that of the unfermented cake, is light, porous, of a more agreeable taste, and more easily digestible. This is undoubtedly the best and most wholsome state to which farinaceous grains can be brought, for the purposes of digestion and nutriment.

These properties of flour have been so well and so long known, that it would have been useless to have mentioned them, if it was not necessary to have them now present in our minds, that we may connect them properly with the discoveries which have been lately made, concerning the constituent parts of flour. I shall only observe further, that if we add to the above some other facts, which were known by chemists, namely, that flour was no more soluble than gums in spirit of wine, or oils, and that when exposed to distillation with a degree of heat, superior to that of boiling water, by which alone, they as well as other vegetable matters, not of the volatile kind, can be decomposed, they yield the same

principles

ciples as all the other bodies do, which are susceptible of the tuous fermentation; it was natural to think, that this sub-e was known nearly as well as it could be. But this matter, h was supposed to be homogeneous, is really not so; and it separating and distinguishing a substance quite different from white feculent part, which predominates in flour, that the ern discovery consists.

is easy to conceive that this substance, different from the ous and feculent matter called *Starch*, but which is in its na-l state intimately mixed with this starch, and which was not eptible in any of the known operations, for the reasons here- mentioned, could not be distinguished and separated from it by some operations of another nature; and this accordingly what happened.

cannot say whether Mr. *Beccari* was the first who thought of ing with cold water, paste made of wheat flour, which was re-, and had not undergone either fermentation or baking, and ontinuing this washing by frequent changes of water, and col-ng each time the remains of the paste, till the water, from g white at first became clear and limpid, and till the remain-part of the paste can be observed to be quite a different substance the other part or starch, which the water had diluted and ied off. I am inclined to believe that this practice was not rely unknown, and was used by some artists to procure a paste, lue more solid than the common one made of starch, fit for rent purposes, such as the joining together pieces of broken celain; but this appears certain, that if this matter was thus wn before Mr. *Beccari*, those who used it, considered it only he strongest and most adhesive part of the flour, and did not ect it to be of a nature essentially different. He was, therefore, first who excited the attention of chemists upon this matter, publishing in the Bolognian Memoirs, a course of experiments de to discover the nature of this substance.

Sometime afterwards Mr. *Kessel-Meyer* made it the subject of a sis, held in the University of Strasbourg; and then several er chemists made it the object of their researches. These re-rches could not fail in procuring an analysis of flour, much more urate than had been made before. Mr. *Rouelle* is one of the who engaged in this matter, with much zeal. I ought here give testimony, that from the year 1770, he gave in his course chemistry, the analysis of corn, from the experiments of Messrs. *ccari* and *Kessel-Meyer*. I saw there, together with all our audi-s, the different products of the analysis of corn made by Mr. *uelle*, and particularly a large quantity of the glutinous matter, ferent from the starch. Messrs. *Beaumè*, *Malouin*, and *Parmentier*, ve also mentioned it in their works. Lastly, Mr. —— Author of

of the French edition of the London Pharmocopeia, has ſince
ſumed this matter, and has done me the honour to invite me to
operate with him in the numerous experiments, which he
undertaken, in order to verify thoſe which have already been ma
and to add many new ones. An account of theſe will be given
his third and laſt volume of the London Pharmocopeia.

Whatever therefore I ſhall ſay concerning the late analyſe
flour is from the above-mentioned chemiſts, eſpecially the Aut
of the tranſlation of the London Pharmocopeia, who has b
pleaſed to allow me to anticipate his account of his new reſearc

When paſte made with wheat flour is waſhed in the manne
Mr. *Beccari*, before it has been fermented or baked, the part wh
remains, after the water can extract no more ſtarch from it,
called the *gluten*, or *vegeto-animal matter*.

The quantity that is obtained of this matter varies much,
this difference proceeds probably from the qualities which the f
receives from the kind of corn whence it is prepared, and fr
thoſe which it receives from the ſoil and ſtate of the atmoſph
having been more or leſs favourable to the vegetation of the co
This quantity extends from a fifth to a third of the whole,
even more, according to Mr. *Beccari*; but its qualities are alw
the ſame, whether its quantity be greater or leſs.

The manner of obtaining this matter pure and ſeparate fr
ſtarch, ſhews that it is not ſoluble, nor even diffuſible in water,
its great tenacity and ductility ſhew that its parts have the p
perty of joining and adhering well together. Thus it forms a n
which has nearly the ſame ſoftneſs as the paſte whence it is p
pared; its colour is a little more grey, and it is much more tenaci
and elaſtic; ſo that it may be extended till it becomes ten
twelve times longer without breaking, and when one ceaſes
ſtretch it, it contracts to nearly its former dimenſions. It may
alſo extended in breadth, and when thus made thin, it has a ſmo
ſurface, and reſembles much in appearance the membranace
parts of animals, ſuch as the cellular membrane, and the epiplo
Its ſmell, when it is freſh, is exactly the ſame as that which is p
ceived in Corn-Mills. In taſte, it is inſipid, and it cannot be dilu
in any degree in the ſaliva by means of maſtication. In order to p
ſerve its ſoftneſs and its extenſibility, it muſt be kept in water.
adheres ſo ſtrongly to all dry matters, that in order to manage
to mould it, we muſt frequently moiſten our hands with water.

This glutinous matter dries very eaſily. And when it is ma
to dry quickly, all fermentation is prevented. It becomes mo
brown when it is dried, and acquires the ſemi-tranſparency
glue, and nearly the ſame ſolidity. When bent to a certain degr
it breaks with a ſmooth ſurface and with noiſe. Theſe qualit
make it fit to ſerve as a glue to faſten pieces of glaſs, porcelain, wo

ven of metal. When it is to be used for this purpose, the s to which it is to be applied must be very dry. It then is made to adhere to them, and when dry, it is unalterable by thing but the liquors that are capable of dissolving it. Water ver, although it cannot dissolve it, reduces it in time to its al soft state.

en it is dried by as strong heat as it can bear without being posed, such as that of an oven heated to bake small pieces of , it swells extremely, so as to occupy fifteen or twenty times rmer bulk, and this expansion is caused by aerial or other rs, which are rarified within it, and form many large cavities. is kind of baking it acquires a little more taste and smell, however, proceed only from the crust being scorched. It then eatable, but is tough like leather, and more incapable ng diluted by the spittle than before it was baked.

his glutinous matter be boiled in water, instead of being put oven, it undergoes a kind of coction, without any swelling, ires a little more solidity, loses almost all its tenacity, its ex- lity, its gluey quality, retains only about as much elasticity as room, and does not become less insipid or more eatable than it efore. The water of the decoction evaporated to dryness no residuum different from that of pure water.

en this glutinous substance is burnt in open air, or distilled tort, it exhibits the same effects and the same products as s purely animal, and not at all like vegetable substances. a piece of this dried glutinous matter is put into the flame ndle, it crackles, becomes black, swells, liquefies in some de- nd flames like a feather, or like a piece of horn, or glue, a disagreeable empyreumatic smell exhales like that of burn- imal substances. By distillation in a retort, a volatile salt irit is obtained and a fetid empyreumatic oil, which has all operties of animal oil. Lastly, the coal which is left, either he combustion or after the distillation, does not differ in any from animal coal. It is not more combustible, nor more e of furnishing fixed alkali by incineration, than the coal of l substances.

e animal character of this glutinous part of flour, is completely inted in the effects of fermentation when it is kept soft, some time longer or shorter, according to the temperature of ; and especially when it has not been perfectly freed from rch, as M. *Beaumé* justly remarks, it acquires the smell and f old Dutch Cheese. I have seen and eaten some of this s of Cheese which Mr. *Rouelle* had prepared, and which he ted at one of our courses in the King's Garden. It resem- exactly the cheese of milk, that if it had been salted, a per- ight easily have been deceived by it. But it appears that it

is to ſome remains of ſtarch that this quality is owing; for w
the glutinous ſubſtance is perfectly freed from ſtarch, and kept
der water in a warm place, it undergoes the putrid fermenta
and acquires a fetid cadaverous ſmell. It is therefore proba
that the mixture of a certain quantity of ſtarch, which tends
ſpirituoſo-acid fermentation, ſuſpends and ſtops the progreſs o
putrefaction of the gluten, and retains it at leaſt during ſome
in the ſtate of imperfect putrefaction of decayed cheeſe. We
obſerve that when the gluten comes to this ſtate of cheeſe, it
be diluted by ſaliva and is very eatable; which change is ent
produced by fermentation.

We have not been able to diſſolve this gluten, when freſh
means of the yolk of an egg, nor by ſugar. Mr. *Keſſel-Meyer* h
ever, thought that theſe ſubſtances had ſome action upon it.
ther oils, nor ſpirit of wine, nor even ether could diſſolve it. S
of wine does however ſeparate from it, by digeſtion, a ſmall q
tity of a ſubſtance which has the marks of a reſinous oil. R
fied ſpirit of wine applied to freſh gluten in a conſiderable qua
does not at firſt occaſion much change; but at length, the gl
is rendered very hard, probably by a kind of drying. It is t
obſerved, that the gluten thus hardened and dried by ſpir
wine, retains the white opake colour which it has when freſh
ſoft, and does not acquire the appearance of glue which it aff
when dried in open air.

Liquid fixed alkali ſcarcely acts upon gluten when cold, and
probably induced Mr. *Keſſel-Meyer* to think that this ſolvent ha
power upon it. But by means of boiling, we have ſeen this d
lution ſucceed very well. The alkaline liquor, after it has a
upon the gluten was a little turbid, and could not be filtrated w
out much difficulty and very ſlowly. After the filtration, we ſ
rated from this ſolution, by means of an acid, a ſenſible quanti
gluten which had been diſſolved; but this gluten did not rec
its elaſticity.

All the experiments which have been hitherto made by diff
chemiſts concur in eſtabliſhing that the oily vegetable acid, ſuc
the cream of tartar and vinegar, are the ſubſtances which beſt
ſolve the gluten and produce the leaſt change in it. And in
experiments I obſerved, that this ſolution was eaſily effecte
vinegar diſtilled or not diſtilled, the liquor being nevertheleſ
ways turbid, ſomewhat milky, and incapable of filtration.
addition of liquid fixed alkali rendered this ſolution of glute
vinegar more turbid and more milky, and the gluten ſepar
from it in the form of ſcum. When thus ſeparated, it was fo
to have its original elaſticity and other characteriſtic properties

When this ſolution of gluten in vinegar is evaporated, b
gentle heat, without any addition, pellicles inſoluble in wate
gradu

lly ſeparated, and at the bottom is formed a kind of mucila- gelatinous and gluey matter. During this evaporation, a ſmell of vinegar was exhaled. As this combination of gluten negar is turbid, probably part of the gluten is imperfectly d, and it is alſo probable, that this is the part which ſepa- form of pellicles during the evaporation, while the part combined with the acid, is found under the form of the ginous matter which occupies the bottom.

ecting the action of mineral acids upon the gluten, we d a difference between our experiments and thoſe of Mr. *Keyer*. This author ſays, that theſe acids do not diſſolve ten; whereas we obſerved, that the three mineral acids, centrated ſtate, acted with efficacy upon this matter, whe- was freſh or dried. The reſult of the repeated experiments Mr. —— has made upon this ſubject, was, that the nitrous ed more quickly, and produced more effervescence than the or marine, that the ſolution in nitrous acid was of a deep colour; that the ſolution in the vitriolic acid was of a dark colour; and that the ſolution in the marine acid, was of a own, with a violet hue. I ſhall not relate here the detail many intereſting experiments which Mr. —— has made eſe combinations of mineral acids with gluten, but ſhall at to himſelf to communicate. I ſhall only obſerve, that eſe experiments, there is reaſon to believe, that when the rated mineral acids diſſolve the gluten, they decompoſe at part of it. This conjecture is confirmed by the obſervation, theſe combinations, a certain quantity of an oily ſubſtance ays ſeparated, which had the ſmell and conſiſtence of fat t had been expoſed to the action of mineral acids; and alſo er many ſolutions in water, or in ſpirit of wine, filtrations, ns, and evaporations in open air, many of which were ed during ſome years, Mr. —— obtained at laſt, without p of fire, from the nitrous ſolution, a nitrous ammoniacal d from the ſolution in marine acid, a marine ammoniacal f the exiſtence and nature of which ammoniacal ſalts we ourſelves by the moſt deciſive proofs, ſome of which were n company with Meſſrs. *D'Arcet* and *Rouelle*. From theſe ments, we learn this important piece of knowledge, that, gh by the application of fixed alkali to freſh gluten, we ot ſenſible of any diſengagement of volatile alkali, it is ne- eſs certain, that this volatile alkali does exiſt ready formed gluten, and ought to be conſidered as one of its conſtituent Is it not the ſame caſe with the volatile alkali which is d by diſtillation, or by putrefaction from animal matters, hich the glutinous part of flour has, as we have ſeen, ſo a reſemblance? This can be known only by a ſeries of ex-

 periments,

periments, similar to those which Mr. —— has ma
gluten, and which he has begun to make on animal m
present we shall confine ourselves to the new analysis o
shall proceed to relate what has been discovered concer
ture and properties of its other parts, of which the m
able is the white mucilaginous fecule, known under
of *starch*.

We have seen, that in order to obtain the glutinous
necessary to wash in much water, the crude and recent p
This washing separates from it the starch which is dif
suspended in cold water, without being dissolved in
that reason gives to the water a white opake milky
while it remains thus suspended. But as it is specific
than water, it gradually subsides, and forms a whi
which is *starch*. But it is very necessary to remark, th
—— has ascertained by experiments, this starch whi
before any fermentation has happened, is greyish,
wants that glossy whiteness of the starch that is sold by
facturers, who allow the liquor to undergo the acid fe
and even some degree of putrefaction, before they
starch. After the liquor has thus fermented, the
which subsides first, is the whitest and best starch.
manufacturers separate carefully the upper part of th
which they set aside as not being fit for sale. The sed
to this is the common starch, and that part which is at
of the vessel is the starch of the best quality.

Mr. —— has imitated these operations. He left a
water which had been employed to wash the paste to
the fermentation which it could. It became very sou
surface a mouldy crust was formed, in which were ma
tions of different colours, but particularly of sever
green. The upper part of the sediment which was fo
bottom of this liquor was of a dirty grey colour, but
part was very white, and after it had been carefully col
washed and dried in open air, it was found to be
white, neither acid nor alkaline, insipid, not capable
a binding paste with water, as flour does; in a word
the starch commonly sold.

It follows from these properties of the feculent part
the flour, that independantly of its not being soluble
ter, it is not even rendered soluble by means of fermen
remains unchanged in a liquor, in which the acid an
mouldy fermentations pass through their several degre
follows from these experiments, First, That the ferment
the white milky water with which flour-paste has been
dergoes, is not owing either to the glutinous matter, f

water, nor to the ſtarch, ſince it is found to be unchanged
s fermentation. In order to find what ſubſtance cauſed the
ntation, Mr. —— evaporated with a gentle heat, a ſuffi-
quantity of this water with which the waſhings had been per-
d, after it had depoſited its ſediments, and before its fer-
tion had begun; and he obſerved that the reſiduum of this
ration was a matter of a yellowiſh brown colour, viſcid, gluey,
taſte very ſlightly ſaccharine, which in combuſtion and in
tion preſented the ſame products and effects as ſugar does,
hich Mr. —— calls properly a mucoſo-ſaccharine matter.
theſe important facts ſhew ſufficiently the cauſe of the dif-
es obſerved between the different ſediments of ſtarch, and
aſons of the obſervations uſed by the manufacturers of that
odity. For we may eaſily conceive that the ſtarch which
es before the fermentation, draws down along with it a part
mucoſo-ſaccharine matter, which adheres to it by means of
cidity, and depraves its colour; whereas the ſtarch which
oſited after fermentation, by which the mucous ſaccharine
is attenuated and deſtroyed, ought to ſubſide more readily
quor deprived of its viſcidity, and become purer and whiter,
e the colouring heterogeneous matter has loſt that viſcidity,
eans of which it adhered to the ſtarch before fermenta-

reover, as ſtarch is the baſis and predominant part of flour,
very important to know what kind of bread could be made
two kinds of ſtarch which I have mentioned, namely, the
nd white. Accordingly Mr. —— has made this experiment.
aker who was employed in making this bread, obſerved that
ſtarches could not make a binding and tough dough, like
nade with flour, that the dough thus made by ſtarch, could
ly be kneaded, was apt to ſplit, that it was almoſt impoſ-
o form it into cohering loaves, and that notwithſtanding the
of which he added a conſiderable quantity, it did not ſwell
ſo much as the dough of flour does. The quality of theſe
, after they had been baked, was found to be ſuch as might
pected. Their taſte, excepting a little bitterneſs which aroſe
the yeaſt, was not diſagreeable nor very different from that of
ary bread, but the cruſt of theſe loaves was much cracked;
had riſen much leſs, and wanted the lightneſs and ſpongineſs
dinary bread; but were on the contrary, hard and dry, which
red their maſtication more difficult; and all theſe faults
more conſpicuous in the loaf made with white ſtarch, than in
nade with the grey ſtarch.

hen the beſt ſtarch that is ſold, is expoſed to diſtillation in a
, it yields nothing but an oily, empyreumatic, brown acid

 ſpirit,

ſpirit, and an empyreumatic oil which is very thick towards the end of the operation.

The difference between the products of ſtarch and of the glutinous matter is, that the latter does only yield the products of ſubſtances perfectly animalized, whereas the ſtarch yields only the principles of vegetable matters. M. *Rouelle* obſerves, that the empyreumatic oil of ſtarch is heavy, while that of the glutinous matter is ſo light, that it ſwims upon the volatile alkaline liquor.

When the entire flour of wheat, or bread made of this flour, was diſtilled, in a retort, by Mr. ——, nothing was obtained, but a ſaline oily ſpirit, which contained an acid and an empyreumatic oil. The volatile alkali of the gluten did not appear in theſe analyſes, becauſe it was combined with the predominant acid of the ſtarch. But by adding to the product of theſe diſtillations, a ſufficient quantity of fixed alkali to ſaturate all the acid, we obtained this volatile alkali by a new diſtillation of the mixture, and it is remarkable, that it appeared to be leſs in quantity in the products of the diſtillation of bread, than of flour.

The reſult of all this inquiry into the nature of flour, is that this matter is not homogeneous, and that it contains three ſubſtances very diſtinct and ſeparable from each other.

The firſt and the moſt abundant is pure ſtarch, or a white fecule, inſoluble in cold water, ſoluble in hot water, and of the nature of mucous ſubſtances, which, when diſſolved, form watery glues. This matter is then ſuſceptible of fermentations, eſpecially thoſe of the acid and mouldy kinds; and it yields, when analyſed, an acid ſpirit, and an heavy empyreumatic acid oil.

The ſecond ſubſtance is the gluten, whoſe properties have been deſcribed, a ſingular matter, which although indiſſoluble in cold water and in hot water, and capable of adhering ſtrongly as reſins do to all bodies that are not wet, has not however any of the other properties of reſins, and other concrete oily ſubſtances, and ſeems to approach to the nature of gums in the reſiſtance it makes to the action of ſpirit of wine, oils, ſaponaceous menſtruums, and ether, as well as by the property which it has to form a glue. But it is not a gum, as appears from its inſolubility in water, and from the principles obtained from it by diſtillation, which are different from thoſe which gums yield. As theſe principles are exactly the ſame as thoſe obtained by analyſing animal ſubſtances, and as the effects of the fermentation, of which it is ſuſceptible, are analogous to thoſe which are produced by animal matters, it is to this kind of compounds that we ought to refer this ſubſtance. Among all animal matters, cheeſe is that to which this glutinous ſubſtance is moſt ſimilar.

Laſtly, the third ſubſtance which is obſerved in flour, is mild, perfectly ſoluble in cold water, of the nature of ſaccharine ex-

tractive

ctive mucous matters, and susceptible of the spirituous fermen-
ion. This latter substance is found in a small quantity in flour,
east in that of wheat; for it is very possible that a larger quan-
 may exist in the flour of other grains.

There can be no doubt but that it is from the union and just propor-
 of these three constituent parts of the flour of wheat, that the su-
iority of this flour depends over all others for making bread, that
ight, agreeable, and salutary. For it is proved by the experi-
nts of Mr. ——— on the bread made with starch, that even
 flour of wheat yields a very inferior kind of bread, when it has
n deprived of its glutinous matter, and a still worse bread,
en deprived of its mucoso-saccharine part.

t is also certain, that the flour of all the other grains of which
ad not so good as the bread of wheat-flour can be made, either
tains less or none of the gluten; for experiments have shewn,
t by treating these different kinds of flour in the same manner
 has been mentioned of wheat-flour, no sensible quantity of
tinous matter can be separated; and these observations seem
demonstrate that it is to this substance of animal nature that the
ır of wheat owes its property of making the most excellent
ad.

t has been considered whether this gluten be nutritive, and
e chemists are of opinion that it is not. But this opinion must
e arisen from want of due attention to the nature of this sub-
ce. For since it is perfectly similar to animal matters, why
uld it not be capable of nourishing as well as they It is true,
t when the gluten is pure, and separated from the other parts of
ır, and when it has not undergone any fermentation, its glutinous
ality and extreme tenacity would render it a very unhealthy, and
ost indigestible aliment: But the case is otherwise, when it is
ided in infinitely fine parts throughout the whole substance of
 flour, and when these parts are separated from each other by
 interposition of those of the amilaceous and mucoso-saccharine
stances of the flour. For Mr. ——— found by experiments,
t the glutinous matter is contained in an infinitely less quantity
 the bran. This gluten is so soluble in this state of division and
tribution, which is its natural state, that the mere degree of heat
 baking, or even the slight fermentation of dough, are sufficient
combine the glutinous with the amilaceous parts of the flour, so that
ey cannot be afterwards separated. When flour is boiled in milk,
 in water, in order to make book-binder's paste, the gluten cannot
 any longer extracted from it; neither can it be separated from
leavened bread, or even from dough which has but begun to
ment, though not baked, and still more from bread fermented
d baked. Several of these trials have been made by Messrs.
ccari, *Kessel-Meyer*, and other chemists. We have repeated all

of them with great care, so that it may be considered
strated truth, that baking and fermentation render th
and mucoso-saccharine parts of flour capable of perfe
its gluten.

Such are the late discoveries which we owe to th
philosophers above-mentioned concerning the constit
flour. They are certainly very interesting in themsel
they not become much more so, if it were possible to
to an object of so great consequence as bread is? Flo
not the only one, as is well known, of which bread is
the breads of other inferior grains, although perhaps
nourishing as that of wheat, are confessedly not so goo
digestible; and as they are cheaper, they are almost th
our peasants. How great then would be the advantage i
could be meliorated without much additional expence.
any method of effecting this, the knowledge which we
acquired on the nature of flour, and an accurate enqu
the other farinaceous matters, are certainly the most pr
on which we ought to proceed. The gluten of whea
does not exist, or in very small quantity, in the
is it not the principal cause of the difference in quality
several kinds of bread, for the greater or less whit
essentially affect their properties? On the other side,
tion and nature of gluten are perfectly known. Its
racter being thus ascertained, seems to indicate that a
to it may be substituted at a low price, among anim
such as the caseous part of milk, jellies or glues o
bones, cartilages, tendons, &c. or even certain vegetab
bages, and turneps, which yield by analysis the same
animal matters. How many experiments and resea
yet to be made on this subject?

M. *Parmentier* has particularly applied his attention t
and frequently communicates to the Academy of Sci
sult of his inquiries, which are not unsuccessful. In
of this chemist, which are not yet all published, we
has particularly examined the amilaceous part of flour
well remarks that this substance, which he justly consi
very nourishing, is much less susceptible of alteration
tion, than the other parts of flour. It is certain, th
makers extract easily from spoilt corn or flour, as g
they could from the best flour. And we are indebted
mentier for his endeavours to make useful applications
Without having any knowledge of the experiments of
at which I assisted; Mr. *Parmentier* made similar expe
object of which was to find out what kind of bread m
from starch alone, and then to discover what substan

of giving to this insipid, and heavy bread, the good qualities
ich it wants. The experiments of M. *Parmentier* have shewn,
hat from potatoes, made into paste with yeast and a little salt, a
read may be formed, which he says is excellent, wholesome,
ery nourishing, and which in times of scarcity may be substituted
or bread of wheat, rye, barley or oats." This is a valuable fact.
is of importance to know that with the starch obtained from
ilt grains and flour, and which may be preserved very long with-
any alteration, it is possible to make a bread light and well-
ed. I, and also several other members of the Academy, have
of this bread made from starch by M. *Parmentier's* process, and
und it to be sufficiently well raised, and of an agreeable taste at
, but afterwards I perceived a bitterness, which it is to be wish-
could be removed. The knowledge we have already acquired on
nature of wheat-flour, and of its constituent parts, gives room
ope that we may be able to carry this bread of starch, and that
he inferior grains, to the highest degree of perfection. This
wledge is at present so far advanced, that we may consider the
blem as already resolved. All the world agrees that the superi-
y of bread of wheat-flour is owing to the gluten, the animal nature
which is ascertained. Analogous, and equivalent substances, are
nd abundantly in the animal kingdom, and even among some
etables. Mr. *Parmentier* has already met with a matter in po-
es, which in a certain degree may supply the place of the
en. But are potatoes the best of all the substitutes that can be
nd? We ought not to admit that they are the best, till accu-
experiments have been made with other animal and vegetable
stances, whose analysis may shew the most perfect resemblance
h the glutinous matter of the flour of wheat. The extent of
se experiments is undoubtedly great, but the research is highly
ortant; for when the best substitute for the gluten is once as-
ained, we shall be able to make bread as perfect as that of
eat-flour, with all the other kinds of flour.

IRE. Chemists consider fire, as also the other elements, in
very different views: first, as it enters into the composition
many bodies, in which it is a principal or constituent part; and
ondly, as being pure, free, not entering into any compound,
acting sensibly and strongly upon all natural bodies, and pro-
ing effects as a powerful agent in all chemical operations. In
latter point of view we shall consider fire in this article. It
be considered as a principle under the article PHLO-
STON.

Pure, free, and uncombined fire seems to be a collection of par-
es of a very subtle matter; and all the properties of this ele-
nt shew that its particles are infinitely small, have no sensible
adhesion

adhesion to each other, and that they are continually agitated by a very rapid motion.

From this definition, fire appears to be a body essentially fluid, and many facts concur to prove that it is the only body essentially fluid, consequently the cause of the fluidity of other bodies; and that as it alone counterbalances the general tendency of all the other parts of matter towards each other, it prevents them from uniting into one immense mass, homogeneous, and as hard as matter can be.

It is difficult to conceive this essential fluidity of fire, this incoherence of its integrant parts, and the rapidity or their movements, by which fire is excluded from the class of aggregate substances, and is therefore different from all other kinds of matter. For the parts of all aggregate bodies evidently yield to general gravitation, and unite together with more or less force, whereas the parts of fire seem to avoid each other, and are repelled with the greatest violence.

This mode of existence of fire, which is indicated by all that we know of its effects, and of its properties, cannot be comprehended according to the hypothesis of attraction; unless we suppose, as a well-known geometrician thinks he has found by calculation, that attraction does only act within certain limits of proximity, beyond which it becomes negative, and is changed into repulsion; or by saying, with the Count de *Buffon*, the parts of fire are endowed with much greater elasticity than those of all other bodies, whence it happens, that when they move towards each other, by the attractive force common to all matter, and come into contact, instead of uniting and adhering together, according to the common law, they rebound from each other by means of their perfect elasticity, and are repelled in a contrary direction, and with a force equal to that which Mr. *Buffon* calls expansive force, and which, although it is produced by the attractive force, does nevertheless destroy or rather continually resists the effects of this latter force, and becomes an antagonist necessary to continue the motion of the parts of matter.

These two ideas appear to me to be equally consistent with the nature of fire, and when they establish a force capable of counterbalancing the force, or rather, the direction, of attraction, they may both serve to explain in a satisfactory manner, the great effects which fire does incessantly produce in nature.

The most obvious of these effects, are the exciting in us the sensations of heat and light. From these alone, mankind in general judge of the presence or absence of fire, so that nothing but what heats and gives light, is commonly thought to be fire. But it is necessary that natural philosophy and chemistry should examine the matter a little more profoundly. Unhappily this exa-

mination

ation is attended with great difficulties. Of theſe, the princi-
s, that when we come to examine all the known effects of
and to compare them, we find it difficult to decide whether
heat and light belong to one and the ſame ſubſtance, or to two
nct ſubſtances. Strong reaſons are alledged for and againſt
of theſe opinions. As a very intenſe light is always accom-
ed with heat, and as a body intenſely heated is always lumin-
it might ſeem that there is but one ſubſtance, whoſe different
es of exiſtence excite in us the ſenſations of heat and light:
on the other ſide, theſe two ſenſations do not accompany each
r with equal degrees of intenſity. Sometimes bodies heated
conſiderable degree emit no ſenſible light, while other bodies
uminous, although not hotter than the ambient bodies. For
nce, boiling water is very hot, and yet gives no light:
le the moon, and phoſphoric bodies ſeem to be very lumin-
although they diſcover no heat. Theſe reaſons are ſtrong
gh to make us preſume that the two ſenſations are excited by
diſtinct matters, dependant however on each other.

ut among the effects of fire in action, there are others, which
y opinion, allow us ſtill leſs to confound light with heat,
ely, thoſe that ſhew that they act very differently on bodies.
certain that no bodies are impenetrable to heat, whereas light
trates thoſe only which are known to be tranſparent, and is
cted more or leſs completely by all the others. But two beings
h ſo differently affect certain other bodies, are neceſſarily
nct, and we ſhall therefore conſider them as different, as ſeve-
ood philoſophers, particularly the Count de *Buffon* have done.
ow that it may be ſaid, that heat and light may be the ſame
ance differently modified; that fire itſelf, with all its proper-
is nothing but the mode of exiſtence of any matter; that
, water, air, in a word, all material ſubſtances may become
and alſo that fire may be changed into earth, air, &c. and
thus all the elements are tranſmutable into each other. The
ſſibility of theſe tranſmutations cannot indeed be proved, be-
e we want, and always ſhall want the knowledge neceſſary to
le of what matter is, or is not ſuſceptible. But the true object
atural philoſophy is not to diſcover what may be, but what
nd we can only conſider as exiſting, thoſe things whoſe
ence is proved. But, this tranſmutability of all ſubſtances
each other, not only, is not proved, but no fact can be
ced to render it probable. It would therefore be in vain to
der too vague ideas, and I only mention them in this place,
uſe they every now and then are brought up even in modern
ngs. I return to the aſcertained effects of heat and light.

s theſe effects are different, it follows, as I have ſaid, that heat
ight are not the ſame thing; but are each of them a ſubſtance

ex-iſting

existing separately and distinct not only from each other, but also from all other material substances? this is another question which is not easily resolved, the nature of fire is too little known to give us hopes that we can have clear ideas upon this subject. All that we can pretend to do, is to propose some conjectures from well known and certain facts.

It is to be observed, that this latter question does not seem to concern light. We cannot really doubt that this being, by means of which we see whatever may be seen, and without which we cannot see any thing, is a substance distinct from all others, since it is the only one capable of rendering bodies visible. We know also from the most decisive experiments, that it has a progressive motion, whose direction is in a straight line, and whose velocity is enormous, of about eighty thousand leagues in a second. It is known to be perfectly elastic, since it is reflected from bodies at an angle equal to the angle of its incidence. It is known to be inflected when it passes very near bodies, that it is refracted when it passes from one medium into another of a different density, which proceeds from its being subject like other matter to the law of attraction. *Newton* has shewn that light is not a simple substance, but that it is compounded of several substances, all which have the fluidity, velocity, elasticity, and refrangibility of light, but which do not possess these qualities, at least, the refrangibility in the same degree. Whence it happens, that when it is made to reflect, inflect, and refract, it is decomposed, and separated into its constituent parts, which then appear to be so many distinct and differently coloured rays. Lastly, chemists have proved by many experiments, (as is shewn at the article *Phlogiston*,) that this substance does actually enter as a constituent part into the composition of a very great number of mixts, from most of which it may be again separated, and combined with other mixts. But, a being whose motion we know, whose velocity we calculate, whose direction can be changed, which can be collected or dispersed, whose constituent parts can be separated or united, which enters into compounds, and from which it may be separated, is very certainly a real substance, and which ought to be distinguished from all other substances, by its peculiar qualities, which no other kind of matter possesses.

In these respects, *heat* is very different from light. We cannot so easily decide, whether it be also a peculiar kind of matter, having the exclusive property of exciting the sensation of *hot*, as light has of rendering objects visible, or if it be only a modification, a mode of existence, of which all material substances are susceptible without distinction, when they are affected in a certain manner.

The

he principal phenomena of heat confift, firft, in this, that the
es which are more or lefs penetrated by it, excite in us, when
ouch them mediately, or immediately, fenfations which we
heat, burning, which are agreeable or painful, according to
ftrength and the real ftate of our bodies.

condly, the bulk of all bodies augments in proportion as they
enetrated with more heat; but fome bodies are more affected
is manner than others, according to their nature.

hirdly, heat does not act as light does, in refpect to the pene-
on or tranfmiffion through bodies. There are many bodies
ugh which light cannot pafs, namely, thofe which are opake.
e is alfo a great part of the light which falls on the moft tranf-
nt fubftances, that is reflected, or fuffers, in its paffage through
es, fo many refiftances and deviations, that it lofes its motion at
th, and ceafes to affect us as light does. But heat penetrates
odies, opake or tranfparent, and is not reflected. It is true that
aftic and heated matter falling upon a body is reflected, and if
matter happens to be invifible like air, it might be thought
the heat itfelf was reflected, but this is an error, as I am in-
d to believe, from the following confideration.

ourthly, heat is diftributed and divided equally among all
es equally expofed to it, however different thefe bodies may be
her refpects, folid, or fluid; hard or foft, denfe or rare, opake
anfparent, inflammable or uninflammable, &c. When ex-
d to the fame degree of heat and in the fame place, thefe
rent bodies become equally heated, as the thermometer fhews;
ough fome arrive fooner than others at this equilibrium of heat,
veral authors, efpecially Dr. *Franklin*, have obferved, but this
rence is not very confiderable. But I fay that this equilibrium
d not take place, if heat could only, like light, pafs through
in bodies, and were reflected from all others, for the fame
ons that bodies of different textures, expofed to the fame light,
not, and cannot be equally luminous.

iftbly, the progrefs of heat is not quite equal in different
iums. It moves with lefs velocity through denfe than rare
iums, and is always infinitely lefs rapid than light. It is not
eptible of decompofition, inflexion or deviation. It's progrefs
rfectly uniform, and not to be diverted.

ixthly, heat diminifhes the fpecific gravity of all bodies, becaufe
ncreafes their bulk. But I believe that no change is thereby
luced in the abfolute weight of bodies. I know that it is pre-
ed by fome, that bodies acquire fome fmall degree of weight
eing heated, but the experiments alledged in fupport of this
ofition do not prove it; firft, becaufe feveral others affirm that
r experiments were not attended with the fame refult, and
ndly, becaufe thefe experiments cannot be truly made, as all
the

the bodies which we know of are capable of receiving changes and alteration, loſs of ſubſtance and accretion of foreign matter, by being expoſed to ſtrong heat; all which circumſtances falſify the reſults.

Seventhly, as it is certain that all bodies, when they cool, recover the ſame temperature which they had before they were heated, and that they do not acquire a greater diſpoſition to be heated again, it follows that they do not retain any of the heat acquired; that heat, in a word, is capabe of ſeparating from bodies as well as of penetrating them, without incorporating with them in any manner, whereas light is capable of combining with bodies.

It appears to me that we muſt conclude from theſe facts, that heat is ſomething entirely different from light, and that it is not even a material ſubſtance, as light is, diſtinguiſhed by peculiar properties. In fact, if heat were a matter, ſince all matter is eſſentially impenetrable, it would be impoſſible to conceive that the parts of this heat, however ſmall they may be, ſhould not meet with ſome obſtacle, ſhould not ſuffer ſome reflection, ſome deviation from the elementary particles of bodies; that they ſhould penetrate theſe particles, or ultimate atoms, which muſt be without pores, and perfectly denſe. And this ſole conſideration appears to me to prove that heat is not a ſubſtance, but is merely a particular ſtate, or mode of exiſtence, of which all material ſubſtance is ſuſceptible, without any change of the nature of ſuch ſubſtance. If we may be indulged in forming conjectures in this obſcure ſubject, I ſhould propoſe the following ideas, to which however I fix no claim, not even that of novelty *, and which I am ready to relinquiſh to adopt any other that may appear more ſatisfactory and conſiſtent with the phenomena of fire.

If it be true that all the parts of matter tend to each other, by means of univerſal attraction, or any other force, we cannot doubt that the elementary and aggregant parts of bodies are ſo placed in relation to each other, that this tendency ſhall be ſatisfied as much as their configuration, their maſſes, and the action of ſurrounding bodies will permit.

On the other ſide, it is univerſally admitted that the moſt denſe aggregates contain many pores or vacuities, and even more of theſe than of ſolid particles; and it therefore follows that the elementary and aggregant parts of all bodies, even the moſt denſe and hard, have room enough to move, and that in fact they cannot fail to move, whenever they receive ſome impulſe or ſhock, whoſe force is ſuperior to that of the attraction by which they are held in their preſent poſition.

But,

* *Bacon* had the ſame idea. It is alſo the opinion of ſeveral modern philoſophers. But I do not know that any have explained it ſufficiently.

ut, if this be the case, it is evident that no solid body can suffer
ions or percussions, without a proportionable derangement of
parts. But as these parts are subject to another force which tends
eep them in their proper situation, they must return or ap-
ch to it as nearly as they can, after the motion impressed by
percussion ceases or diminishes, and this alternative being kept
by the continuation of frictions or of percussions, an intestine
ement of oscillations and vibrations in all the minute parts of
body rubbed or struck necessarily follows, and this movement
much the stronger, as these oscillations are the more rapid.
it seems that this intestine motion is sufficient to produce in
bodies the state which we call heat, and to give a satisfactory
on for all the effects of which this heat is the cause, as we
see from the following remarks.

. If heat actually consists in this intestine motion of the parts
odies, every body which suffers frictions and percussions ought
e proportionably heated. Accordingly this is confirmed by ex-
ence, since it is certain that all bodies become so much hotter
hey are rubbed or struck with more force and celerity.

. Heat dilates bodies more or less also, according to their na-
, and in proportion to its intensity. This effect ought necessa-
to take place, if heat consists in the shaking and vibration of
parts of bodies. For these parts cannot move without a respec-
change of place, and consequently without ceasing to be as
iguous to each other, as they were before they had acquired
motion.

. The absolute weight of bodies is not augmented by heat,
ever great, and it cannot indeed be augmented, since it is pro-
ed only by the motion of the parts of the heated body, without
introduction of any new matter into this body.

. Heat is not reflected, for it is not possible that any thing but
aterial substance, as light is, can be reflected; for heat being
y a mode of existence of a material substance, it cannot be there-
reflected, although heated bodies may.

. The heat of bodies is communicated to surrounding and con-
ous bodies, is divided equally among them, and is reduced to a
d of equilibrium. But this effect ought necessarily to take place, if
t be nothing else than the motion of the parts of bodies. In this
ance we only observe the general law of the communication of
tion, which is always distributed with equality and equilibrium
ong all the bodies which move and strike each other.

6. It is impossible that heat should be fixed in any body, and
perience shews that in fact it never is fixed. The same explica-
n is here applicable. Nothing can be united to substances but
er substances. But by the supposition, heat is not a substance,
articular matter, which possesses in a peculiar manner a hot qua-
lity.

lity. It therefore cannot be fixed in any body; and accordingly bodies are only hot when exposed to causes productive of heat, such as frictions and collisions, which put in motion their elementary and aggregant parts; and their heat diminishes and ceases always in proportion as these causes diminish and cease to act.

7. The light which falls upon bodies heats them so much more as it is more intense, and this is a necessary effect of its nature and violent motion. Light is a material substance, its parts are indeed so small that they can pass through the pores of all transparent bodies. But the dense particles of those bodies are not pervious to light, which can only strike upon these particles and be reflected. And when we consider the prodigious velocity of the parts of light, we must perceive that they must strike the bodies on which they fall with great violence, notwithstanding they are so minute, and that when concentrated, as in the focus of a burning glass, they may agitate instantly the parts of bodies to which they are applied, to such a degree as to produce the most violent heat that is known.

8. All bodies heated to a certain degree by collisions, even by those which are different from those of light, become nevertheless ardent and luminous in proportion to their heat. This is certainly a very remarkable effect. To explain it we must observe, that light itself is not visible, or sensible but when it is darted from bodies directly to our eyes; otherwise it makes no impression on us; so that we do not so much as suspect its presence. For this reason it is, that we do not see light during night, although excepting the small cones of the shades of the earth and other planets, the whole extent of the sphere of the sun is as much filled with the light of this luminary during night as day. This proceeds from the light not being directed towards our eyes, and therefore no other part of it is visible but that which falling upon bodies capable of reflecting it, such as the moon and other planets is darted towards our eyes by this reflection. For the same reason, we do not see the focus of a burning glass it then does not fall upon a body, although there is incomparably more light in this focus than in the surrounding space. For when we place in this focus a body capable of reflecting the light to our eyes, it then becomes very sensible, and dazzling to our sight. This being the case, it is evident that if a body passes from a state which does not permit it to dart towards our eyes the surrounding light, to another state which renders it capable of producing that effect, this body from being not luminous at first, will appear, and really become so much more luminous as its new state renders it more fit to dart to our eyes a greater quantity of light, and with more rapidity. But this is precisely what happens to cold bodies when they contract much heat by friction or percussion. Before they were heated, their elementary and aggregant parts were at rest, or at least had but little

motion; but as soon as they enter into violent vibrations, as they npervious to light, they necessarily strike with violence the of light which are contiguous to them, and dart them on all Hence these bodies become shining like so many small according to the intensity of their heat.

om the two last articles, (No. 7 and 8) we see how heat and mutually excite, or rather render each other sensible, although ese the latter be a particular material substance, while the r is a modification which may belong to any matter. If we ve in certain bodies, and in certain circumstances a very sen- degree of heat, while these bodies do not appear to us more ous than other bodies that are less heated, the reason is, that cannot make a sensible impression on our eyes, unless it be di- l and darted towards them with more force and velocity than e communicated by the collision of the particles of bodies, a have but little motion. The velocity of light ought certainly proportionable to the sensibility and irritability of our organs. annot doubt but there are degrees of light which we do not ive, but which might be perceived by animals whose eyes were than ours. It is even very probable, that if many men were k in the dark at bodies so heated, as not to appear luminous st of them, some of them might nevertheless be able to dis- ish these bodies. This experiment has not I believe been , but it certainly deserves to be. The same may be said of n bodies which give more light than others without being heated. It is probably owing to our thermometers not being ently sensible, that we cannot discover the greater heat of bodies which are slightly luminous (for it is these only that this case) over those which are not luminous.

night further add here many other considerations on the pro- on of the effects of light with those of heat, which several ular circumstances might make appear unequal, although it vertheless always the same. It is very possible, for instance, of two bodies of equal bulk and equal heat, heated to the same e, and which consequently dart the same quantity of light, and the same velocity, one may appear much more luminous than other. For this difference may be produced by one body ng parallel or convergent rays, while the rays of the other body ge. But these explanations of the phenomena of heat and of , and many others which naturally occur, would lead me too I shall only add here a reflexion which is a consequence of heory which I have explained on the nature of light, which at if it consists only in the vibrations of the elementary parts dies, by whatever means they are put in motion, it follows he parts of no body are ever in a state of perfect rest; or at ... perfect rest would be accompanied with absolute

F cold,

cold, which probably does not exist in nature, on account of the motion of light, and the constant action of bodies upon each other.

We see from what has been said on the nature and effects of light and heat, that what we call *disengaged* or *active fire*, is nothing else than the result of the motion of light, and also of the motion of the particles of all bodies, occasioned either by the impulse of light, or by some other impulse, and that this motion is communicated to the light which it darts in all directions. Thus two causes may produce the effects of active fire, namely, first, the impulse of light, and especially when this is possessed of its greatest velocity and intensity, as it is in the focus of a burning lens or mirror: Secondly, the frictions, percussions and collisions of bodies. The phenomena of active fire are always so much the more sensible as these two causes act more strongly: They diminish when they act with less force, and they cease when the causes cease to act. This happens, in general, to all bodies into the composition of which the matter of fire, or rather that of light does not enter, at least in a sensible quantity, as one of their principles. But there is in nature, and especially on the surface of the globe, a great many mixtures which exhibit all the phenomena of active fire, in a more permanent and more durable manner than all others, and which therefore deserve to be particularly considered. These are bodies called *combustible* or *inflammable*. What distinguishes these bodies, is that when they are once put into an igneous motion, that is, when they are made red hot, either by the collision of bodies, or by the impulse of pure light, or by the contact of any body which is in this igneous motion, they produce all the phenomena of active fire, they become burning and luminous, and preserve these qualities in the same degree, or in an encreasing degree, without the necessity of the continued action of the causes which excite active fire, as in the case of incombustible bodies, and they remain in this ignited state, till all the light which entered into their composition be disengaged: after which, the part of those bodies that remains, becomes of the class of those that are incombustible, and cannot resume or preserve its state of ignition, like combustible bodies, without the continued action of the causes which excite the active fire, as is explained more fully at the articles COMBUSTION and PHLOGISTON.

As combustible bodies produce, of some sort of their own accord, and while they are ignited, all the effects of active fire, and as there is plenty of these combustible bodies, we make use of their combustion more conveniently than we could frictions or the motion of pure light, in order to apply the action of fire to any substances, in the operations of the arts and chemistry. Thus the combustion of these bodies may be considered in this respect, as a

third

cause which excites the activity of fire, or rather as fire itself, ed of all its liberty and activity.

er these different explanations of the nature and effects of fire, we may easily form an idea of the manner in which it pon different bodies, and of the changes which it makes them go. Experience proves that it causes decomposition only by unicating heat. Thus, although light be the sole substance can be considered as the matter of fire, it is not as light, or property of rendering bodies visible, that it produces the of fire, but by the impulse, or violent motion which it unicates to the constituent parts of bodies, which motion, as already said, constitutes essentially and solely the state which l heat. This being well understood, no doubt can remain he manner in which I conceive the effects of active fire, and he alterations which it produces in the bodies exposed to on.

peak properly, all these effects are reduced to a single one, or y its consequences. This principal effect is the dilatation bodies; and this dilatation can be only attributed to heat, reasons I have given. But it is evident that no body can ated, without a proportionable diminution of its specific y, of its hardness, or adhesion of its parts; and these two es are the most essential to be considered relatively to che-; for every operation of this art is effected either by the ition of specific gravity, or by a greater or less disjunction parts of bodies, as we shall shew.

e substances are capable of a greater dilatation or diminution r specific gravity, than others, by fire. Thus certain mat- e so much rarefied by even moderate heat, that they seem to l their specific gravity, or become at least specifically lighter ll the surrounding bodies: hence these substances, when to a certain degree, are raised as bodies would be without y. All substances which have this property are called in l *volatile substances*. Other bodies are so little dilatable by elatively to their density, that the greatest heat that can be to them, produces an almost insensible diminution of specific y. These are called, from their being almost unalterable in spect by fire, *fixed bodies*. Hence, if we expose to fire a ound body containing some fixed and some volatile principles, ter becoming specifically lighter, ought to rise in vapours, separate themselves from the former, which are unalterable respect. But as almost all compounds contain principles ng so much in volatility and fixity, that some of them may sed and sublimed, while others shall remain fixed with some degree of heat; we may therefore, by heat alone, make many ses and decompositions. If, for example, we expose a com-

 pound

pound of regulus of antimony, which is a volatile semi-metal, and of gold, which is a fixed metal, to heat so strong that the volatility of the regulus of antimony shall take place; then this semi-metal, being raised by its acquired levity, will be sublimed in vapors, and will be separated from the gold, which will remain fixed and pure. The observation we have just made concerning the changes in the specific gravity of bodies, which the dilatation occasioned by heat produces, ought also to be applied to the diminution of the adhesion of their integrant parts, which is an effect of the same cause; for if a body be dilated by heat, the contiguity, and consequently the adhesion of its integrant parts must be diminished: but in this respect, the several natural substances differ very much; for the integrant parts of some bodies, when dilated by heat, are so separated and disjoined, that they seem no longer to cohere. If these bodies be naturally solid, they become fluid when they are penetrated with a sufficient quantity of disengaged fire, and are called *fusible bodies*. Those bodies, the integrant parts of which cannot be entirely disjoined by fire, are called infusible or refractory: but as the aggregation of a body is broken when it is fused, and as this destruction of aggregation is a necessary condition for the combination of bodies with each other; fire, therefore, by rendering solid bodies liquid, has influence as a principal agent in all combinations.

As all chemical operations may be reduced to decompositions and combinations, fire is, therefore, in chemistry, as in nature, an universal agent. Thus we know, that although decompositions and analyses may be made by menstruums without any more than the natural heat, yet as these menstruums can only act when rendered sufficiently fluid by heat, fire therefore acts in these analyses as necessarily as in those which are occasioned by the immediate application of heat. We ought to observe concerning this subject of the volatility, fixity, fusibility and infusibility of bodies, first, that all these properties are properly only relative. Not any body is entirely fixed and infusible; and those which we consider as such would be reduced into vapors, as volatile bodies are, if they were exposed to a heat infinitely stronger than any we can excite. Thus a body will appear fixed, or infusible, when compared with other very volatile and very fusible substances: While it shall be considered as volatile or fusible, when compared with others more fixed and less fusible. In the second place, as volatility and fusibility are effects of one and the same cause, namely, of the dilatation occasioned by the presence of a certain quantity of uncombined fire in bodies, these two qualities are properly the same, in more or less eminent degrees; and in this sense, volatility ought only to be considered as the highest degree of fusibility. Accordingly, substances which are habitually liquid, and which ought therefore

considered as the most fusible, are all very volatile, and m...
sed into vapors with very little heat; while, on the contrary,
rs that are hard, and not very dilatable; those, in short, the
gation of whose parts is the firmest and most dificultly to be
en, and which are therefore the least fusible, are also the most
The aggregation of all bodies, when reduced into vapors or
, is broken; but more so when reduced into vapors, than
merely fused. Accordingly, the most effectual of all methods
mbining substances which cannot be easily united, or which
ot be joined while the aggregation of one of them is sensibly
rved, is, if possible, to reduce them into vapors, and to make
vapors meet. All the effects which fire produces, as an agent
emical operations, are reducible, as we see, to those we have
ioned. The quantity of uncombined fire which flows per-
lly from the sun, and diffuses itself through all its sphere, is
ent to produce all the separations and combinations which
ily see effected by nature: but as the heat caused by the sun
y limited, chemistry would be confined almost to the contem-
on of natural operations, if we had not methods by which pure
ncombined fire may be made to enter bodies, or to quit them
eater or less quantities.

e method of encreasing the quantity of fire or of exciting its
ty, are, 1. The impulse of concentrated light. 2. Frictions.
e combustion of inflammable bodies.

e strongest action of light that we know of is, that of the focus
urning lens or mirror. The heat which this focus excites in
s exposed to it, is even much too strong for most chemical
tions, and ought to be applied only to the most fixed and most
ctory bodies. As the focus is besides very small, and these
tions cannot be without great difficulty performed conveni-
in it, and as powerful mirrors and lenses are very rare and
very little use is made of this fire for the operations of che-
y. This Science is however indebted to it for many experi-
s of the utmost importance, as the *decomposition of gold*, pub-
by *Homberg*, if it be true, the *fusion of platina* which I have
ed along with M. *Beaum*:, and that of several other bodies
h cannot be fused by other fires without addition, as has been
n by different Chemists.

e heat which is excited by frictions and percussions is in gene-
roportionable to the force, to the rapidity, to the extent of
riction or percussion, as well as to the hardness of the bodies
ed or struck. This heat is also little used in chemical opera-
; but appears nevertheless very frequently in many experi-
s, as in fermentations, effervescences, solutions. It takes
whenever bodies unite together, and is proportionable to the
and rapidity with which these bodies re-act upon each other.

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It is produced by the friction and collision of their parts; which indicates that the primary particles of bodies are of the greatest degree of hardness, even in those bodies which are habitually liquid or soft; for these bodies, during their solution or re-action, are capable of producing as much heat as the hardest substances; and if the agitation of some fluids does not produce any sensible heat, the reason is, as M. *de Buffon* says, that their parts cannot touch or strike each other in such a manner as to produce a sufficient collision.

As to the combustion of those bodies that are combustible, it is, as I have said, the most convenient and advantageous method of applying the action of fire to bodies.

The most common inflammable substances, such as wood, pit-coal, charcoal, and oils are those which are generally used in Chemistry, as well as in the Arts and in common life, for all the operations in which the action of fire is wanted.

Chemists having occasion for all the degrees of heat from the weakest to the strongest, have sought and found the means of procuring them by employing different intermediate substances, and still better by the disposition and construction of furnaces, in which are contained the combustible matters and the substances to which the action of fire is to be applied.

It is certainly not without grounds that the *Count de Buffon* remarks in the first volume of his introduction to the history of minerals, that the action of fire upon different substances, depends greatly on the manner in which it is applied. Experience proves in fact, that certain matters which melt easily enough in the fire of a forge or of a large furnace, resist the focus of a burning lens or mirror, although this focus melts other matters which are infusible, or whose fusion requires great time, by any other mode of applying heat. To explain these facts, M. *de Buffon* thinks that we ought to consider fire in three different states, the first relative to its velocity, the second to its bulk, and the third to its mass. Under each of these points of view, according to this illustrious Author, this element so simple, so uniform, in appearance, will seem to be a different element. M. *de Buffon* explains afterwards how we may encrease the velocity, the bulk, and the mass of the fire, and make it produce different effects according as its activity is encreased by one or other of these means. I cannot but applaud the new ideas which this ingenious man proposes on this subject, and which appear to me to be generally well founded. Nevertheless, as each person has his own manner of considering things, and, as M. *de Buffon* himself expresses, the empire of opinion is sufficiently large for every one to wander in it, as he pleases, without offending each other; I will hazard a few words concerning my sentiments on the differences of the effects of fire, from the ideas which I have explained in this article, on the nature of this powerful agent.

Fire

[F]ire does not act or produce any alteration upon bodies, but by [mea]ns of exciting heat in them, and heat is nothing but the mo[tion] of the constituent and aggregant parts of heated bodies.

[I]f these propositions be true, we can safely conclude that the [mea]sure of the action of fire is the product of the mass of heated [bod]ies by the velocity of the vibration of their particles; and this [bein]g the case, it is evident that as we have not any means of en[cre]asing the velocity of the light darted from the sun, we cannot [enc]rease its heat but by encreasing its density, as is usually done in [the] foci of catoptric and dioptric instruments, as M. *de Buffon* [just]ly remarks. I believe we may add, that for the same reason, [wh]en we heat bodies by frictions or percussions and independantly [of t]he action of light, we cannot encrease their heat by any other [mea]ns, than by encreasing the oscillatory velocity of their parts, [by] rubbing or striking them more strongly, or rapidly, since it is [evid]ent that by friction or percussion, the mass of the bodies rubbed [or s]truck cannot be changed. We see then two cases in which the [acti]on of fire may be increased, the former by augmenting the mass, [and] the latter by augmenting the velocity. But these two fires, [esp]ecially the latter, are of no use in chemical operations, for the [reas]ons above assigned. The fire which we are most inter[ested] in the knowledge of, is that of combustion. The effects of [this] fire may be greatly encreased, we cannot say how much, by [enc]reasing the access of air, and bulk of burning matters. But as [this] fire results from the disengagement of light, and from the in[test]ine motion of the parts of the burning bodies, we cannot so [easi]ly know, whether its force be encreased by augmenting its mass [or i]ts velocity. Perhaps the encrease of velocity may take place [in a] certain degree by the communication and augmentation of the [vibra]tions of a great many ignescent and contiguous parts. But as [far] as I can judge, this effect is only secondary, and occasional in [suc]h cases, and for the following reasons.

I grant that a fire of combustible matters which becomes infi[nit]ely hotter and more luminous by the blowing of bellows, or by [any] other rapid draught of air, has very much the appearance of [a fi]re whose activity is encreased by a new degree of velocity im[pre]ssed by the current of air; but this is only an appearance, or I [am] much deceived. In fact the impulse of air upon a burning [bo]dy, cannot encrease the velocity of the fire, but by encreasing [tha]t of the parts of bodies put in motion by combustion, or that [of] the light which is disengaged in this combustion. But, it ap[pe]ars to me that the strongest impulse of air cannot produce either [of] these effects. For, first, it is certain from experience, that the [im]pulse of the air pushed upon any body with the greatest known [vi]olence cannot agitate the parts of this body so strongly as to pro[du]ce any sensible heat. The most impetuous, natural or artificial

wind is not able to produce any alteration in the temperature of bodies. Besides the impulse of air can still less accelerate the velocity of light, not only because its greatest velocity is so exceedingly small when compared with that of light, but also because it is not capable of any sensible hold upon the parts of this substance, as is demonstrated by a well known experiment. We know in fact, that the most violent blast directed upon the focus of a burning glass does not produce any change, neither augmenting, or diminishing its activity, or altering its direction.

But if it be asked by what means then does a current of air encrease so considerably the activity of all kinds of fire which proceeds from combustion, I shall make the following answer.

All philosophers agree that air is an ingredient or agent absolutely necessary to combustion, that the most combustible bodies cannot burn without its immediate contact, and that the more compleat this contact is, the more active is the combustion. This being the case, it is evident that if we encrease the quantity of air which comes into contact with the parts of any combustible body, we shall proportionably augment the quantity of those parts which burn at one time; but as it is the quantity of ignescent particles in the same space that is thus encreased, it follows clearly, that it is then the mass of fire and not its velocity which is thus encreased.

With regard to the augmentation of the effects of fire, by encreasing its bulk, it requires other considerations. Heat being really nothing else than the motion of the parts of heated bodies, all the phenomena of heat cannot differ in any respect from the phenomena of moving bodies; and it follows from thence, that the communication of heat from one body to another must be exactly similar to the communication of motion from one body to another. But motion is communicated according to certain laws, which indeed vary as the hardness and elasticity of the striking bodies vary; but it is certain, that in general, whatever be the velocity and density of moving bodies which strike other bodies at rest, these qualities being determined and remaining the same, the bodies that are struck receive so much more motion from the striking bodies as the latter surpass the former in number and in bulk, and *vice versa*; so that if a considerable quantity of matter at rest is struck by a very small quantity of matter in motion, it will not thereby be sensibly moved, whereas its motion will be very great, if these circumstances are reversed. It follows from hence, that in order to produce a determinate motion in any given quantity of matter, by the impulse of a quantity of matter in motion, of a given velocity and density, it is necessary that the quantity or bulk of this moving matter should be proportionable to the quantity or bulk of the body to be moved, and in order to procure this determinate degree of motion, in the matter which is to be moved,

it

ought to be ſtruck by a proper quantity or bulk of the matter
at is to communicate the motion. Now, in applying theſe in-
nteſtable principles to the communication of heat, we ſhall ſee
at it follows the ſame laws as thoſe of the communication of
otion. In fact, if heat be nothing elſe than the motion of the
rts of heated bodies, as I ſuppoſe it to be, it follows, that in
der to produce a determinate heat in any body, ſuch as the heat
ceſſary for the fuſion of that body, it muſt be expoſed to the
tion of ſome other matter in the ſtate of igneous motion, the
antity or bulk of which are proportionable to the quantity or
lk of the body to be melted. This truth is proved by a very
ple and common experiment. It is known that glaſs or iron
ay be melted at the flame of a common candle, as well and as
ickly as in the largeſt and hotteſt furnaces; and that this de-
nds ſolely on the relation of the bulk of the matter to be melted
th that of the fire which is to melt it, ſo that the bulk of the
re of glaſs or of iron thus expoſed to the flame of the candle be-
g ſmaller relatively to the bulk of the flame, than the bulk of a
ge maſs of ſeveral quintals of theſe matters, is with regard to
at of the fire of the furnace, the fuſion will be more compleat and
ick in the former than in the latter caſe.

Theſe facts appear to me to furniſh a new proof of the analogy
tween the phenomena of the communication of heat, with thoſe
the communication of motion, and the reſult is, that in what-
er manner the fire be applied to any body, whether its activity
augmented by an encreaſe of its velocity, of its maſs, or of its
lk, its effects are always exactly the ſame, on the ſame body,
hen the degree of heat communicated to it is the ſame; and that
white and diaphanous bodies, for inſtance, reſiſt more the fire
catoptric and dioptric foci, than the fire of combuſtion, the rea-
n is, that theſe bodies are really leſs heated in theſe foci, which
nſiſt of a pure light, that they have the property of reflecting or
anſmitting, than in the fire of combuſtion, in which, beſides the
rts of pure light, the parts of the igneſcent bodies which are
obably denſer than thoſe of light, do conſequently ſtrike them
ith more force. I have lately made ſome very ſimple experiments
hich I have communicated to the academy of ſciences. They
nſiſted in expoſing to the focus of a burning glaſs, ſeveral plates
glaſs of different degrees of whiteneſs and thickneſs, without
pport, and holding them at the end of a pair of tongs. When
e thickneſs was equal, the glaſſes which were leaſt white, melted
oſt eaſily and quickly; which agrees very well with the fact al-
ady known, that coloured bodies heat quicker and ſtronger than
hite bodies in the rays of the ſun. But what is moſt remarkable
d important in theſe experiments, is, that with equal degrees of
hiteneſs and tranſparency, the thickeſt glaſſes melted more eaſily
than

than the thinner; ſo that a plate of glaſs as thin as paper, which could be melted inſtantly in the flame of a candle, was not even ſoftened in the focus, which however, melted pretty large pieces of iron, and made them dart ſparks to the diſtance of a foot.

This experiment ſeems to prove, that bodies expoſed to the mere action of light, receive ſo much leſs heat, as they have more of the property of reflecting, without being penetrated by the rays, as was already known; and further, that their heat is alſo ſo much leſs, as they give a freer paſſage to the rays of light; and it follows evidently from thence, that the bodies which are capable of being heated the moſt ſtrongly by the action or impulſe of light, are thoſe which reflect the leaſt, abſorb the moſt, and tranſmit the ſmalleſt quantity. But how ſhall we conceive the production of the moſt violent heat in theſe latter bodies, unleſs we conſider heat to conſiſt in the agitation and oſcillatory motion of the ſmalleſt parts of theſe bodies, occaſioned by the impulſe of thoſe of light? Why ſhould ſo much light be able to penetrate within the bodies, and not be able to paſs through eaſily and freely, and leave them? Certainly we cannot imagine any other reaſon, than the colliſions of the particles of light againſt theſe of the bodies which it heats, theſe colliſions being ſo much more multiplied, as light penetrates in greater quantity into bodies, or as it meets with more obſtacles to its motion in a right line, by which means it is reflected, and turned in a thouſand directions within the bodies, before it can get out of them, while it loſes as much of its motion as it communicates to the reſiſting particles of the bodies by all theſe colliſions. Does it not follow clearly, that light can heat bodies only in proportion, as it communicates its own proper motion to their parts, and that conſequently heat is nothing but the agitation and motion of the heated particles?

I have hitherto been of opinion, I confeſs, with moſt natural philoſophers, that heat was a particular kind of matter, ſo ſubtle as to penetrate all bodies, and to ſeparate their parts, when put in action by light or by percuſſion; and that this being was the true matter of fire; but the above reflexions have ſuggeſted a very different opinion. There certainly is a matter of fire: and it is pure light, which is a material ſubſtance, whoſe exiſtence cannot be queſtioned. But we cannot ſay the ſame of heat; the cauſes which excite it, and the effects which it produces, do not prove, or even ſuppoſe the exiſtence of a particular matter. They all concur on the contrary to indicate that it is only an accident, a modification of which ſome bodies are ſuſceptible, and conſiſting merely in the inteſtine motion of their aggregant and conſtituent parts, and which may be produced not only by the impulſe of light, but alſo by all frictions and percuſſions of any bodies.

Additions to the Article GOLD *of the former Edition.*

THE fixity of gold, although very great, is not perfect, no more than it is of other bodies, which have been considered the most fixed. This fixity is only relative to the degrees of heat, to which these bodies may be exposed. Accordingly, gold is not truly fixed, and does only resist without loss the action of the fire of furnaces, for if it be exposed to a much superior heat, such as that of a large and good burning glass of three or four feet diameter, it is certain that it suffers, even in a little time, a sensible loss. I have held some very fine gold in the focus of a burning glass belonging to the academy, at several times, and during half an hour each time, sometimes in a hollow piece of charcoal, or in vessels made of earthen ware and porcelain, and whenever the air was very clear and the sun very bright, I and several other members of the academy observed, that a very sensible smoke arose from the gold to the height of three or four inches. To know what was the nature of this smoke, I exposed to it a cold silver plate, by which means some of the vapour appeared upon the silver like a tarnish a little less white, but not sensibly yellow. But when this part of the silver plate was rubbed with a burnisher, it appeared so evidently to be gilded, that none of the persons present could doubt that the smoke of the gold which was thus fixed to the silver, was a portion of the gold itself reduced into vapours by the violence of the heat of the focus.

Some chemists pretend to have *calcined gold*. *Homberg* says, in the ancient memoirs of the academy of sciences, that having exposed gold to the focus of *Tschernhausen*'s great lens, he has seen it smoke, and reduced to a green violet colour. But according to the tradition which is preserved in the academy, this experiment has not all the authenticity that is necessary, and it requires to be repeated with the greatest care.

As it was an experiment of great importance, I thought it proper to verify it, after the academy had charged me together with Messrs. *Montigny*, *Cadet*, *Lavoisier*, and *Brisson*, to make a course of experiments with the great burning glass belonging to the academy, which was the same as that which Mr. *Homberg* had employed. I exposed gold of twenty-four karats fine several times to the focus of this glass, during half an hour at a time, on dishes made of very refractory white porcelain earth.

When the gold was melted, which happened in the space of some seconds, it took a spherical form, excepting on the side where it touched the support, and where it was flattened by the weight of the mass, precisely as happens to mercury, and this sphere soon acquired a rotatory motion round its axis, sometimes

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in one direction and sometimes in another, according as it received the impression of the focus more vertically, more horizontally, or more laterally, and whether from one side or from the other.

At the same time, when the focus was at its greatest heat, a very sensible smoke arose, as Mr. *Homberg* had observed, and the nature of which I determined by the experiment above mentioned.

On the surface of the spheres of gold, I saw gradually formed; spots evidently vitrified, which separated from the gold, and re-united upon most of the spheres into one mass of a dark violet coloured glass, and of a greater curvature than that of the mass of gold, in which they were found to be set as jewels are in a ring, and producing nearly the same appearance as the transparent cornea has on the globe of the eye, that is, as the segment of a small sphere joined to the surface of a greater. I have obtained upon a semi-spherical mass of gold, whose diameter was about half an inch, which might have been exposed to the focus, about four hours in all, a button of this violet glass whose diameter was more than two lines; and this glass was observed gradually to increase, while the gold diminished. It is very probable, that the violet glass obtained by Mr. *Homberg*, was of the same nature as mine. These glasses do certainly resemble much a vitrification of gold: Yet I do not think that we can conclude with certainty the vitrescibility of this metal; because, although I have not remarked any vitrified parts upon the earthen supports that I used, it is nevertheless possible, that some parcels of these supports, or some atoms of dust floating in the air, especially as our experiments were made in a garden, might have furnished the matter of these vitrifications. I think that in order to decide upon the nature of this vitrified matter, this experiment ought to be carried as far as it can go, that is, the gold ought to be exposed to the focus, till all the gold be vitrified or evaporated, till nothing remains but this violet glass, of which there ought to be a sufficient quantity to determine whether it can be revived into gold by addition of a phlogistic matter, like the other metallic glasses; but the experiment carried to this point would be much longer and more difficult than could be believed from several reasons, of which I shall speak at the article BURNING GLASS, and principally from the few days which can be found in this climate, sufficiently favourable to such experiments. This is so much more difficult and thorny, as the gold in the focus is in several different states, and mixes more or less with the vitrified matter. For independantly of the portion of gold which evaporates without being decomposed, the bottom of the earthen vessels, or the hollow of the charcoal in which I exposed this metal to the focus, were always observed to be coloured, even at a considerable distance from the place where the gold rested, with a purple

purple matter, and sprinkled with many small globules of gold not decomposed, some of which are sensible to the naked sight, but which are multiplied prodigiously when examined by the microscope. Many similar particles of gold may be also seen in the violet glass. This purple state of gold is not yet well known; it appears nevertheless to be a kind of calcination of this metal by which it is rendered capable of being vitrified. But we may easily perceive, that before we try the reduction of the purple glass which I have obtained, it will be necessary to expose it to the focus till all the little particles of gold with which it is sprinkled, should be entirely vitrified, or evaporated. I shall not neglect any opportunity of prosecuting and compleating this experiment; but as it is very possible that the time which I have to live will not be sufficiently long for that purpose, I shall leave to the academy of sciences the materials of these experiments with notes, that they may be continued and finished after my death.

Addition to the Article FULMINATING GOLD.

THE effects of fulminating gold have made several chemists, and particularly myself, conjecture that the fulmination was caused by the detonation of a part of the nitrous ammoniac salt that is combined and adheres to the fulminating gold in its precipitation. This explanation appears in fact so much the more natural, as in all the processes known till very lately, for the preparation of fulminating gold, a nitrous ammoniac salt will be formed; as this salt has the property of detonating without addition, and as the augmentation of the weight of the precipitate, seems to indicate, that a portion of it combines very intimately with gold in its precipitation. But Mr. *Bergman* has overturned this hypothesis in an excellent memoir which he published some years ago upon this matter.

The interesting and numerous experiments which this illustrious chemists relates in his memoir, prove clearly that the nitrous ammoniacal salt, and the nitrous sulphur, have no part in the fulmination of gold. The most decisive is, that Mr. *Bergman*, after having dissolved without nitrous acid, a precipitate of gold that did not fulminate, gave it a strong fulminating property by precipitating it again with volatile alkali. From Mr. *Bergman*'s experiments it appears, that neither vitriolic acid, nor fixed alkali, nor washing with a large quantity of distilled water, even when boiling, are capable of depriving fulminating gold of its fulminating property; and that inflammable bodies, such as ether, are more capable of producing this effect. But the most astonishing and remarkable circumstance is, that Mr. *Bergman* was able to destroy the properties of fulminating gold, by interposing between its parts

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any body, by a trituration (which ought to be carefully managed) and by a calcination, with the strongest degree of heat that it could bear without fulminating, which required no less dexterity and attention. These facts, added to the light which Mr. *Beaumé* says he has perceived upon fulminating gold when ready to explode, prove that it is owing to the sudden and instantaneous inflammation of some very combustible matter. But what this combustible matter is, has not been yet determined. Mr. *Bergman* has only proved that it proceeds from the volatile alkali which transmits it to the precipitate of gold; and from a great many experiments which he has made on this matter, it appears that he was not able to make fulminating gold without volatile alkali, and that on the contrary, he has obtained some that was strongly possessed of the fulminating property, by applying this saline matter to this metal when much divided. It appears then to be certain, that gold does not become fulminating, but by the means of volatile alkali. But how does it happen that volatile alkali and gold, which separately do not produce any detonation, and are not even susceptible of an evident inflammation, form with one another a compound capable of the most sudden and violent inflammation that is known? This remains to be determined. As at present we can only make uncertain conjectures concerning the cause of this phenomenon, I shall not attempt to explain it. I shall observe only to those who would examine this matter, that the properties of volatile alkali, and especially those by which it differs from fixed alkalies, have long ago demonstrated to chemists, that a sensible quantity of the principle of inflammability enters into the composition of this saline substance, and that Dr. *Priestley* has lately found in his experiments upon gases, that volatile alkali is one of the saline matters which is capable of assuming the aerial aggregation, that is, of a permanently elastic fluid, and that in this state it is possessed of a strong degree of inflammability.*

Addition to the Article GRAVITY *of the former Edition.*

ALTHOUGH general and particular *gravity*, which is nothing else than *attraction*, be demonstrated by a number of facts, it is of so great importance to the theory of chemistry, that we cannot support it on too many proofs: and therefore I ought to mention here one of the finest experiments which have been lately made in natural philosophy, and which seems to me to demonstrate this great principle in the most sensible manner. Mr. *Morveau* is the author of it. He judged, with reason, that it was essential to demonstrate the existence of a *particular attraction* even to persons little conversant in chemistry, by an experiment made on bodies so large, as to render it infinitely more striking and more sensible than it

* See the Treatise on Gases, Chap. X and XV.

is in the chemical operations, in which it is exerted only by
lecules so very small as to be quite out of the reach of our senses.
exhibited this capital experiment before the academy of sciences
Dijon, (of which he is an illustrious member) in February,
73, and he published it in the first volume of *Rozier's Journal*,
d also in the first volume of his *Elements of Chemistry*. If this
re the only experiment on the subject, it would sufficiently
ve the chemical attraction, which Mr. *Morveau* makes the basis
his theory. It is thus related. "If a balance be put in equili-
o, at one arm of which is suspended a round plate of glass,
ose diameter was two inches and a half, by means of a hook
ened to the upper surface of the arm of the balance; and if
s piece of glass be made to descend upon the surface of the mer-
y, placed below at a small distance, it will be necessary to add
he scale at the opposite arm of the beam, a weight equal to
e gros, and eighteen grains, in order to disengage the glass
m the mercury, and to overcome the adhesion resulting from
contact. The experiment succeeds equally well in an ex-
usted receiver, and therefore is not affected by the compression
the atmosphere, but is merely the consequence of *attraction*."
is proof is evident not only to chemists and to natural philoso-
ers, but also to others.

This fine experiment is rendered still more decisive, and more
ative to chemistry, by the methods in which Mr. *Morveau* has
ied it. Instead of the glass plate, he substituted plates of dif-
ent metals and semi-metals, of an inch in diameter. And as
se metallic substances have different degrees of affinity with
rcury, they accordingly shewed different degrees of adhesion,
ich are shewn by the following number of grains which were
quisite to separate each of these substances from this metallic
id.

Gold	required	446 *grains.*
Silver	——	429 ——
Tin	——	418 ——
Lead	——	397 ——
Bismuth	——	372 ——
Zinc	——	204 ——
Copper	——	142 ——
Regulus of Antimony		126 ——
Iron	——	115 ——
Cobalt	——	8 ——

The most remarkable circumstance in these experiments, (the
ults only of which I mention, and I refer to Mr. *Morveau*'s pub-
ations for the details) is that the order of the adhesion which
s observed between the different metals and mercury, is pre-
sely that of the affinities of these matters to each other, as they
appear

appear in amalgams, precipitations, and other chemical operations, and marks the degrees of the greater or less solubility of metals by mercury, as they have been ascertained by known observations. See the *Tables of Affinities* at the article *Affinity*. "Nobody can (Mr. *Morveau* judiciously adds) be tempted to consider, as a matter of chance, an analogy so constant, and a correspondence between so many effects. It is then demonstrated, that the cause of adhesion is the same as that of solution, and that as attraction is the principle of the former, it is also the principle of the latter."

Mr. *Morveau* proceeds farther, and he even hopes to be able to subject chemical affinities to calculation, and to estimate them with mathematical accuracy. "Here we have (says he) affinities determined by numerical relations. Thus we may say, that the affinity of mercury with gold is to the affinity of mercury with zinc, as 140 is to 204; and it is evident what accuracy would be introduced into chemistry by these mathematical expressions. We have reason to hope, that when we shall have, by experiments purposely made, collected a sufficient number of these terms, geometry resting her calculations, at first upon false suppositions, and afterwards rectifying her results by comparing the same effects in different circumstances, will one day come to demonstrate rigorously the figures which the elements of certain bodies ought necessarily to have, in order to produce a certain determinate sum of points of contact; and to exhibit, after they are re-united, these masses that are regularly subjected to certain forms."

This is certainly one of the finest prospects which we can have in chemistry. And although it does not appear to be without foundation, it belongs solely to geometricians to determine what may be considered as possible in this matter.

I cannot better terminate this article, than by adding the specific gravities of metals, determined by Mr. *Brisson* with more accuracy than has been done before. I shall only repeat the principal results of the experiments made in order to determine the specific gravities, and I refer to Mr. *Brisson's* memoir for the detail. The specific gravity of each metal has been compared by Mr. *Brisson* with that of rain or distilled water, of which the French cubic foot weighs 70 French pounds; and the air being at the temperature of the 14th degree above zero, according to Mr. *Reaumur's* thermometer, the weight of any bulk of water being supposed to be 10000, an equal bulk of each metal, not being hardened by beating, and when very pure, was found to be according to the expressions in the following table:

Specific

I R O N.

	Specific Gravity.	Weight of one cubic inch.			Weight of a cubic foot.			
		oz.	gros.	grains.	pounds.	oz.	gros	grains.
ter	1000							
ld	19257,2	12	3	62	1348	1	0	41
er	10474.3	6	6	22	733	3	1	52
pper	7788	5	0	28	545	2	4	35
s	8395,8	5	3	38	587	11	2	26
ged iron ry soft	7788	5	0	28	545	2	4	35
English Steel	7833,1	5	0	44	548	5	0	41
d	11352,3	7	2	62	794	10	4	44
ofCorn- , pure.	7291.4	4	5	58	510	6	2	58

. B. The specific gravity of metals hardened by being beat found to be a little more, according to Mr. *Brisson*'s memoir. Mem. de l'Acad. des Sciences, 1772. Partie. 11.

Addition to the Article IRON, *of the former Edition.*

TAHL has advanced that *marine acid* treated with iron can acquire the properties of *nitrous acid*; but without foundation. Mr. *Macker*, and more especially the *Duke d'Ayen* have ex- ned this fact. This research gave occasion to the *Duke d'Ayen* ake the numerous series of fine experiments, which are re- l in four memoirs communicated to the academy of sciences, *he effects of the combinations of acids with metallic matters.* To e memoirs I am sorry that I am obliged to refer for many in- lling particulars. I shall only in general take this opportunity nnouncing them to chemists, and of saying, that the title shews great extent of this subject, and that notwithstanding the un- mon zeal of this nobleman, he has not yet been able to com- t in all its extent the task he has imposed on himself. The four noirs above-mentioned are upon the subject of the combina- s of nitrous acid, marine acid, aqua regia, and acid of vinegar copper, iron, tin, lead, and zinc. Although several of the ts of these acids with these metallic matters, were already wn, many new ones could not fail to occur in the exact, but rtunately too little practised, method which the *Duke d'Ayen* loyed in his research. The acids and metals used were ectly pure; the combinations were made with much larger ntities of matter than are usually employed in experiments. weights of the materials, the degree of concentration of the s, the phenomena of their action upon each metal, the quan- of the metal dissolved by each acid, have been all carefully ascer- ed. Lastly, the different degrees of adhesion of the acids to

G the

the metals have been determined by the beſt method which chemiſtry affords; namely, the decompoſition of the metallic ſalts by a graduated heat. By diſtilling each of the combinations in retorts, firſt with a ſand bath, and afterwards in the naked fire, the *Duke d'Ayen* judged of the quantity of each acid that remained united with each of the metals at equal degrees of heat, from the degree of concentration of the acid that paſſed into the receiver, and from the weight of the reſiduum; and theſe intereſting experiments have proved ſtill more completely than had been done before, that marine acid adheres much more powerfully to metals than nitrous acid does, and that it alters them much leſs in their compoſition.

But independently of theſe general reſults, the ſame experiments have preſented to the *Duke d'Ayen* many particular phenomena, which are very curious, and ſeem to be capable of leading to important diſcoveries. For example, to return to the combination of marine acid with iron, mentioned in this article; the decompoſition of the marine martial ſalt, which reſults from the union of theſe two ſubſtances, yielded by diſtillation and by calcination, the moſt ſingular products, which this experiment alone could have diſcovered. With a moderate heat, nothing paſſed into the receiver but a kind of phlegm ſlightly acid; which ſhews that this acid adheres ſo ſtrongly to the iron, that it can reſiſt the action of the fire that is neceſſary to deprive it of all its phlegm, and may be be concentrated to dryneſs in this marine martial ſalt; in which reſpect it differs much from nitrous acid. But when the *Duke d'Ayen* applied to this combination a much ſtronger heat, very different effects followed. A part of the concentrated marine acid was carried off, and, (as this acid uſually does) raiſed along with it a portion of the iron, under the form of a red, ochery, very ſtiptic and very deliqueſcent ſalt, among which there were alſo ſome red cryſtals that were not deliqueſcent. What is very remarkable, is, that, at the ſame time, there was ſublimed to the arch of the retort, a cryſtalline matter, extremely light, conſiſting of laminæ formed like razors, perfectly white and tranſparent, and decompoſing light like the beſt priſms, ſo that, according to the direction in which they were viewed, they exhibited the various colours of the rainbow.

The ſubſtance which remained at the bottom of the retort after the matter had been ſublimed, was a ſtyptic and deliqueſcent marine martial ſalt, ſingularly brilliant, in its colour, and in its form foliated, ſo that it reſembled Muſcovy-talk ſo perfectly, that it could not be diſtinguiſhed from it but by the touch.

Laſtly, this martial talky ſalt expoſed to a ſtill greater heat in an earthen retort, yielded another ſublimate no leſs ſingular than that above-mentioned, but of a very different kind. It appeared

e form of a metallic matter, consisting of small and brilliant par-, which lined the upper part of the vessels. The minuteness ese metallic molecules is such that it could not be discerned e naked sight, nor even by a magnifying lens, whether their was regular. But a good microscope discovered them to be regular bodies, very opake, of the form of flat slices cut off gonal prisms, that is to say, like the earthen-ware tiles used aving floors. These ferruginous crystals, whose facets have olour and brilliancy of the best polished steel, do not seem to a saline state, but appear to be iron itself sublimed by the of fire and by means of the last portions of marine acid. It tain, that they were attractable by magnets.

e may judge from this abridgement of what is said in the *Duke*'s memoir, concerning the combination of iron with marine how many new and curious discoveries may be made, by simi-searches, on the subjects supposed to be the best understood emistry. I shall have occasion to quote several other disco-, no less interesting, which have been the fruit of the *Duke*'s first researches in chemistry.

e means which he employed was not those of a person who t only for a frivilous amusement in taking a superficial view ubject, without searching to the bottom those points which d not very brilliant; they were still less those of certain nders to chemistry, whose sight seems to be so dazzled by the marvellous, or blinded by avarice, that they are not sensible e importance of any truth, but those which flatter their chime-expectations: but they were the means of true philosophers, eding in a regular and connected progression from experiment periment, not in order to force nature to pronounce oracles rmable to our pre-conceived ideas, but to receive the accurate ers which she never fails to give to those who in a proper man-nterrogate her.

e marine martial salt, made by distilling iron with spirit of is soluble in spirit of wine. Although it be very deliquescent, y nevertheless be crystallised, when it is considerably reduced aporation, and afterwards left to cool. The form of its crys-is in very small needles heaped confusedly one upon another. ay be melted, as Mr. *Monnet* remarks, with a very gentle heat.

getable acids are also capable of acting upon iron. We learn the memoirs of the *Duke d'Ayen*, quoted above, that radical gar dissolves filings of iron by means of heat, but with less than the mineral acids do; that this acid adheres very weakly on, since it may be easily separated from it by distillation; that his operation, no part of the iron is sublimed by the acid of gar; and that the remaining iron is so little altered by having thus dissolved, that it retains its magnetic property.

 Mr.

Mr. *Monnet*, who made the fame combination, without having known the memoirs of the *Duke d'Ayen*, which are not yet printed, fays, in his treatife on the folution of metals, that the folution of iron in radical vinegar, when faturated, is red as blood, that it paffes with difficulty through the filter, and lets a quantity of ochre depofite; that it has not nearly the fame ftipticity which the combinations of iron with mineral acids have; that, by evaporation, fome ochre was precipitated; and that by the fubfequent cooling, fmall, oblong, brown cryftals were formed; that this falt when put upon burning coals, eafily parts with its acid, and is reduced into a martial calx of the colour of Spanifh fnuff, which is again foluble in acids and capable of being attracted by magnets. Thefe facts agree very well with thofe obferved by the *Duke d'Ayen*.

Tartar acts alfo upon iron, and even very fenfibly. But the combination of thefe two fubftances is not yet well known, becaufe tartar is a very compound fubftance, whofe proximate principles fuffer alterations and feparations, during its action upon other matters. Combinations of tartar with iron have been made long ago for the ufe of medicine, fuch as the *tartarifed tincture of iron*, *martial extract*, *martial foluble tartar*, *martial balls*; but from want of a diftinct knowledge of the different conftituent parts of tartar, what happens in thefe combinations was not well underftood.

Since Meffrs. *Duhamel*, *Margraaf*, and *Rouelle* have difcovered that a fixed alkli ready formed and united with the other principles of this faline compound, other ideas have arifen concerning the combinations of tartar. Mr. *Monnet* thinks from fome experiments which he has made, that the acid of tartar is the marine acid difguifed by the oily and earthy matters to which it is united in the tartar. This may be the cafe; but if it be fo, it remains to be explained how this difguifed marine acid is affected in the different combinations of tartar, both relatively to the portion of fixed alkali which makes part of the tartar itfelf, and to the other fubftances on which the tartar acts? And this is what I believe is far from having been cleared up. Mr. *Monnet* does indeed pretend to explain, his treatife on the folution of metals from page 77 to 90, all the complicated effects which occur in thefe combinations. But I confefs that after having many times read over and over, with all the attention I could give, the explanations of this able chemift on this fubject, I could not clearly underftand his meaning. I leave to Mr. *Monnet*'s readers to determine whether the fault lies in my want of penetration, or in his expreffions not being fufficiently clear. At the article *tartar*, I fhall relate what is at prefent known concerning this faline fubftance, which is certainly much compounded, and which, Mr. *Monnet* fays, has been an inexplicable enigma; till he undertook to explain it.

Mr.

Monnet has also made some experiments on the combination
tive salt with iron; and the result is, that these two matters
nite and form a salt in very small yellowish, silky, opake
s, which cannot be dissolved in less than four times the quan-
water that is necessary for the solution of pure sedative salt,

Addition to the Article MILK *of the former Edition.*

ILK. It is proper to observe, that as milk, and consequently
whey, do not contain any principle more volatile than water,
g of these compounds is lost by exposing them to any degree
not greater than that of boiling water. Thus by evaporating
n a water-bath, all its parts are obtained confounded with
ther, and separated from the water in which they had been,
f them dissolved, and others only mixed. M. *Bucquet* has
ed, that milk exposed to the heat of distillation, suffers a co-
on similar to that which happens to animal lymph, and that
oagulation cannot be attributed to the loss which the milk
s of its watery part; for the residuum cannot be again dis-
in water, even with a boiling heat.

man, who has made interesting researches upon cow's milk,
mparisons with that of several other animals, has imagined,
y re-dissolving all that is soluble in water, of the ex-
f milk, he could obtain a liquor analogous to whey; and in
the water ought to take up from this extract, some of the
o-sacharine matter, the salt of milk, and the other saline sub-
which milk contains, without dissolving any or but very lit-
the butyraceous and caseous parts, which are not naturally
e in water, and whose connexion with the other parts of the
ought to be diminished by the effect of the heat of a long eva-
on. The butyraceous part swims on the surface of the water,
e caseous remains undissolved in it, as the coagulated animal
n does. When this liquor, which may be thus charged at
re with the principles of whey, is filtrated, it becomes the
ration called *Hoffman's whey*; it is much less used than ordi-
whey, because the latter is more expeditiously and easily pre-
. The late Mr. *Geoffroy* has given an analysis of whey when
ed in a retort. His process consisted in evaporating to dryness
liquor in a water-bath. He afterwards distilled this residuum
naked fire, and he obtained at first some phlegm, afterwards
id spirit of a citron colour, then an oil which was pretty
, and lastly a kind of coal remained, which became moist
exposed to the air, undoubtedly on account of the saline mat-
hat were mixed with it.

his analysis does not teach us much. But several modern che-
have published their experiments on milk. As their discoveries

consist of facts, none of which ought to be neglected; as these chemists do not perfectly accord as to the facts they mention, and as a very distinct account of these discoveries is given in the *Journal de Medicine* for *March* 1773, by M. *Rouelle*, I will here add that article.

"Whey (prepared without cream of tartar) when evaporated nearly to the consistence of a syrup, and exposed in a cold place, yields crystals which are the *salt* or *sugar of milk*. The liquor in which these crystals are formed, being decanted, then evaporated a second time, yields more crystals, which are still the salt of milk. The remaining liquor may be a third time evaporated, and a new crystallization may again take place. This last salt contains some crystals of the febrifugal salt of Sylvius, and no common marine salt. At last, a kind of mother-water remains, or coloured liquor, composed chiefly of mucus, by means of which it frequently becomes a jelly. It contains also a portion of extractive matter.

Two gros of this mother-water, diluted in twice its quantity of distilled water, did not in any respect alter the colour of syrup of violets.

If a dilute acid be poured upon this mother-water, no sensible effervescence happens.

If, upon the last crystallizations of the salt of milk, or upon its mother-water, a strong vitriolic acid be poured, a slight effervescence is excited, and vapours of marine acid are raised. This acid evidently owes its origin to the febrifugal salt of Sylvius abovementioned.

A pound of salt or sugar of milk, being distilled in a retort, yields first, a little phlegm; secondly, an acid; thirdly, an oil; fourthly, a caput mortuum, or bulky coal remains in the retort, perfectly resembling the coals which are produced in the distillation of mild sacharine mucous substances, as honey, manna, starch, sugar-candy, &c. This coal has not the properties of a fixed alkali, and does not effervesce with acids, as the coal of tartar does.

This calcined coal left very little ashes, scarcely the weight of half a gros. These were also very black, and consequently contained some coal not perfectly calcined.

These ashes lixiviated with an ounce of distilled water, changed the colour of the syrup of violets to a green. When mixed with acids, no effervescence was occasioned. These ashes therefore contain only an exceedingly minute quantity of fixed alkali.

The products of the distillation of this salt of milk are then very like those of starch and of sugar-candy.

I burned in an iron dish a pound of this salt of milk. From the coal, when thoroughly calcined, I obtained only twenty-four grains of ashes; and these ashes gave no more fixed alkali, than those did which

h were procured from the caput mortuum of the distillation of f milk.

he latter crystallizations of the salt of milk, and its mother-r being burnt, and their ashes lixiviated, yielded a little febrifu-alt of Sylvius, and a very small quantity of fixed alkali, which ars to me to have proceeded from the small quantity of extrac-matter that is contained in the mother-water, as is already ioned.

pound of the salt or sugar of milk that is commonly sold, being t in an iron dish placed over a good fire, the salt melted in some ee, and acquired the colour of burnt sugar. It exhaled a smell ly like that of honey, manna, starch or sugar, while these ers are burning.

this combustion, the salt of milk smells nearly as strong as sugar ; which property all sweet saccharine bodies have. The coal h remains after the ceasing of the flame, if it be kept red-hot s a small blueish flame ; which effect may also be observed in s.

he ashes which result from a pound of salt of milk, weigh from ty-four to thirty grains, and are still blackish.

hese ashes lixiviated in an ounce of distilled water, give a n colour to syrup of violets, but occasion no effervescence with s, because the alkali is in too small a quantity.

burned also a pound of sugar-candy in a new iron dish. This r melted more perfectly than the salt of milk had done. The e which it yielded did not appear more considerable, nor did it onger.

he coal which remained after the flame had ceased, when kept hot, burns like other coals, with a slight flame unaccompanied smoke.

This coal when reduced to blackish ashes, weighed from twenty-to thirty grains. These ashes are very slightly alkaline, and their bulk we may judge of the small quantity of alkali which y contain.

t appears then that sugar-candy gives nearly the same products alt or sugar of milk. When I say nearly, the reason is, that I not see any certain difference, either in the quantity of ashes, or fixed alkali.

n fact, the salt of milk approaches nearly to the state of sugar-dy. One part of water is required to dissolve two parts of sugar-dy ; and in order to dissolve sugar of milk, a little more than an al quantity of water is required. I do not know any other mat-in the vegetable kingdom, to which the salt of milk is more similar.

 evaporated and dried, in an iron vessel, twenty-five French nts (each pint being equal in measure to two pounds of water) of v's milk, and I heated it so much as to [illegible]. When the

flame

flame ceased I reduced the coal into ashes. These ashes being carefully lixiviated, I evaporated this lixivium to dryness, and I obtained a saline matter, which weighed nine gros and 48 grains.

I examined this salt with much attention, and found that it contained not more than a gros and a half or two gros of fixed vegetable alkali, of the nature of the alkali of tartar.

The rest was a true febrifugal salt of Sylvius. Vitriolic acid being poured upon this salt, the marine acid was disengaged, and vitriolic tartar was formed.

I decomposed some of this salt by the nitrous acid, and thereby a true nitre was formed.

I ought to observe, that the milk on which, or on its products all my experiments were made, was taken in the months of December and January. We might suspect that milk taken the summer months ought to yield very different products from that which is taken in winter: But without foundation. The salt of milk which is made for sale is brought from Switzerland, and is prepared only in summer. Its analysis, as above-described, shews that the summer-milk yields no more fixed alkali than that which is procured in the winter months.

When I estimate the quantity of fixed alkali obtained from milk at two gros, which is the utmost it can be estimated at, it appears that a French pint of milk yields five grains and a half of alkali. When we consider how much of this alkali is carried off in making butter or cheese, it will appear that the quantity remaining in whey, ought to be no more than results from the above trials. We find an analysis of the whey of cow's milk in Mr. *Beaume*'s Manual of chemistry. This analysis has been objected to mine, as invalidating my experiments. M. *Beaume* has indeed obtained after a third evaporation and crystallization of whey, some crystals of ordinary marine salt. He found afterwards in the mother-water, or the liquor which cannot be further crystallized, a fixed alkali which is obtained without combustion. He also distilled some salt of milk, and the residuum in the retort was (says he) a fixed alkali. Lastly, M. *Beaume* adds, that sugar of milk has many properties in common with cream of tartar, excepting that it is not acid.

As this analysis, which is also found in his Elements of Pharmacy, is contradictory to mine, I think it is proper to transcribe it at length, that the public may repeat the experiments, and determine upon the subject.

"Cow's whey, three fourths of which having been evaporated, yields at first a salt that has a sweet saccharine taste, and which is therefore called salt or sugar of milk. This salt is obtained by the first crystallization. The most concentrated acids have no sensible action upon it. This salt is nevertheless saponaceous. If it be exposed to the action of fire in a retort, some empyreumatic oil is obtained.

mined; and the residuum is a fixed alkali. This sugar of milk s besides many properties in common with the cream of tartar, cepting that it is not acid.

"When the liquor is again evaporated, it yields by crystallization alt nearly similar to the preceding. But the mineral acids dempose it. The third evaporation of whey yields crystals of comon sea-salt. Lastly, a liquor remains which will not crystallize: contains some fixed alkali and a small quantitity of extractive atter. This fixed alkali is obtained without combustion.

"Each pint (French measure) of cow's whey, contains about ven or eight gros of the salts above-mentioned.

"We have reason to conjecture that all these salts come originally m the vegetables with which animals happen to be fed, and ich have not changed their nature by passing into the anil body."

uch is the result of the labours of two of our most able chemists. *Paerner* quotes in the notes which he adds to the German transon of the Dictionary of Chemistry, a dissertation of M. *Vulga*-z, *de Sale lactis essentiali, Lugd. Batav.* 1756. As I have not en able to procure this work, I shall only mention after M. *Paer*-, that M. *Vulgamoz* gives an analysis which he made of the salt milk, and says, that the properties which he observed, shew that s *salt is saponaceous, unites oils with water, and is analogous to the* e *of sugar-canes.*

NICKEL, Nickel is a metallic substance, the discovery of ich was published by Mr. *Cronstedt*, a celebrated Swedish mineralist in two memoirs inserted in the acts of the Academy of Sciens at Stockholm, for the years 1751, and 1754.

This matter is the regulus of a very compound mineral, which s believed to contain copper, although nobody had been able to tract any from it: Hence the German metallurgists had given it e name of *Kupfer-nickel.* This mineral is found in several Geran mines, and probably in those of other countries, although it is re. The colour of this mineral is sometimes grey, and sometimes hining yellowish red.

Some metallurgists, especially *Henckell* and *Cramer*, have referd kupfer-nickel to the cupreous and arsenical ores. Mr. *Crondt*, after a more particular examination of it, maintains that this ineral contains a metallic matter peculiar, and different from all ose hitherto known, to which he gave the name of *regulus of nickel*, simply that of *nickel*, under which name it is now known.

Although most chemists have adopted Mr. *Cronstedt*'s opinion ncerning the substance, some however continue to maintain that pfer-nickel contains copper, cobalt, iron, and arsenic. It appears be certain that this mineral, and even the regulus, until it be urified by laborious and difficult processes, does contain some cobalt,

balt, some arsenic, and also iron; but we shall soon see, that although copper may be found in some kinds of kupfer-nickel, the most decisive chemical experiments have not been able to shew the presence of any part of this metal in any of those kupfer-nickels which have been submitted to the most rigorous, and most judicious docimastic analysis.

The experiments of Mr. *Cronstedt* had sufficiently proved that the ore of nickel was not a copper ore, and that the metallic substance obtained from it was either a new semi-metal, essentially different from those before known, or, at least, a particular allay of several metals which it is very difficult to distinguish and to separate. Mr. *Cronstedt* not having pushed his experiments far enough to purify perfectly the regulus of nickel, our knowledge of the true nature of this regulus was but little advanced. We shall, in fact, see, that notwithstanding the later researches, much more considerable and extensive than those of Mr. *Cronstedt*, doubts still remain on the nature of nickel; and as it has been shewn, by these experiments, that what was considered by Mr. *Cronstedt* as very pure nickel, was very far from being really so, it follows, that we cannot depend on the results of the experiments concerning the allays which Mr. *Cronstedt* relates in his two memoirs, and that these results have been prematurely inserted in some modern books of chemistry, particularly in the English edition of the Dictionary of Chemistry, in the notes subjoined to which, many excellent things are contained.*

This nickel, which Mr. *Cronstedt* had but in a manner announced, would have remained among those many substances which are but imperfectly known, and concerning which we should not have been able to have formed any distinct idea, if two excellent chemists had not published very lately the most extensive researches that seem possible to be made on this subject. These numerous experiments are related in a dissertation in the form of a thesis, entituled, *Dissertatio chemica de Nicolo, auctore Johanne Alzalio Arvidsson. Upsali.* As all the resources of chemistry appear to have been exhausted in this excellent memoir, in order to attain an accurate knowledge of Nickel, I shall extract from it what appears to me of the most importance, although this analysis is not perfectly complete, the mineral not having been examined in close vessels. As Mr. *Arvidsson*'s intention was however rather to examine the regulus of nickel than the mineral itself, his examination

* See the *note* referred to at the article NICKEL

this regulus may be confidered as a very good model for
ch refearches. †

This chemift employed the common procefs ufed in effays, as
r. *Cronftedt* had done, to obtain the regulus from the mineral
pfer-nickel, which was previoufly well roafted, fo that by the ex-
lfion of the fulphur and arfenic, it fuffered a diminution of weight
ual to thirty per cent. The colour of the calx was green, and
s the more intenfe as it was richer in regulus.

By fufing thefe calxes, according to the ufual procefs, in a cru-
le expofed to the violent heat of a forge, with a mixture of three
rts of black flux, and a fufficient quantity of decrepitated fea-falt
cover the whole, Mr. *Arvidffon* obtained buttons of different
ights according to the richnefs of the minerals employed, but
ceeding half the weight of the crude ore. The fcoria was brown
black, and fometimes blue.

Such was the regulus of nickel that was examined by Mr. *Cronftedt*.
t the further experiments of Mr. *Arvidffon* proved that the
ckel obtained by this procefs was very far from the degree of
rity to which it muft neceffarily be brought, although not with-
t confiderable difficulty, to enable us to determine its nature.
his perfect purification is fo difficult, that although the very long
emoir of Mr. *Arvidffon* contains nothing but the refults of a very
nfiderable number of experiments of all kinds made for this pur-
fe, we cannot with certainty fay that it has been entirely attained.

The firft attempts of purification made by Mr. *Arvidffon* confifted
long continued calcinations of a regulus of nickel of *Suabia*,
hich had been prepared by Mr. *Cronftedt* himfelf, and in the re-
ction of this regulus after each calcination. Each of thefe fuc-
ffive calcinations lafted from fix to fourteen hours; they were
peated fix times, and they expelled from this pretended regulus va-
urs of arfenic, and alfo white vapours which had not an arfenical
nell: and after all thefe calcinations, in feveral of which powder
charcoal had been added, which method is known to be very
fectual to facilitate the expulfion of arfenic, the metallic buttons
oceeding from the reductions, and whofe weight was diminifhed
each operation, did neverthelefs emit an arfenical fmell, and
ere attracted by the magnet. Six fucceffive fufions of this fame
gulus, with quicklime and borax, after it had undergone the
ove-mentioned fucceffive calcinations and fufions, left a metallic
utton, furrounded with the quicklime which had acquired a green-
h colour, and under a hyacinthine-coloured fcoria. This button
was

† Although I mention Mr. *Arvidffon*'s name only, becaufe he is the
thor of the thefis it is however probable that Mr. *Bergman* directed the
perations.

was ſtill capable of being attracted by the magnet, was ſemi-ductile and tough, and when broke, it appeared to conſiſt of a ſtriated texture.

Laſtly, in order to terminate this long and toilſome work of purification by calcinations, reductions, and fuſions, Mr. *Arvidſſon* calcined a ſeventh time, during fourteen hours, a metallic button which had already undergone all thoſe proofs, till by adding powder of charcoal, no more arſenical fumes were exhaled, and no further diminution of weight was occaſioned. The calx which was produced by this latter operation, had a ferruginous colour mixed with very ſlight traces of green, and after the reduction of this calx, a very ſmall globule remained in the ſcoria which was much charged with iron, and this globule was ſtill attracted by the magnet.

Mr. *Arvidſſon* was not ſatisfied with making theſe trials on a ſingle kind of nickel, but he tried ſeveral kinds from different countries, and the reſults have always been the ſame, that is to ſay, a metallic button has been obtained which was attracted by the magnet, and which conſequently contained iron.

The obſtinacy with which iron remained united with theſe metallic buttons, notwithſtanding the means employed to purify them, ſuggeſted to Mr. *Arvidſſon* the idea of trying other proceſſes, and particularly by intermediate ſubſtances. Of theſe ſubſtances, ſulphur being one of the moſt efficacious to ſeparate iron from other metals, has been tried in repeated fuſions, and added at four different times, without rendering the regulus, when freed from the ſulphur, leſs capable of being attracted by the magnet.

The eſſays made by means of liver of ſulphur, were not attended with more ſucceſs.

Neither was the iron ſeparated more effectually by the long detonations, calcinations, fuſions with nitre, either of the ore or of the regulus of nickel.

Theſe experiments did only ſhew that nitre is capable of diſcovering the preſence of regulus of cobalt in nickel, although it did not appear by any other mode of trial.

Mr. *Arvidſſon* had no more ſucceſs in endeavouring to deprive this regulus of the iron which it contains, by ſublimation with ſal ammoniac, which in many ſubſtances is an efficacious method. The buttons which remained after theſe repeated ſublimations with large quantities of ſal ammoniac, were indeed only weakly attracted by the magnet, but were nevertheleſs ſenſibly attracted. A remarkable circumſtance was obſerved, which was, that although the weakneſs of the magnetiſm of the regulus, which had been thus treated, ſeemed to ſhew that a conſiderable quantity of iron had been ſeparated from it by ſal ammoniac, the flowers did not however appear to be martial, being white, and not producing a black colour when added to an infuſion of galls. But in theſe experiments, theſe

re was always a portion of saline matter which appeared, that s less volatile than pure sal ammoniac, and was tinged by iron a hyacinthine colour. At each sublimation, some volatile alkali sed at first into the receiver, then some undecomposed sal ammo- c; and lastly, a little acid of salt, as generally happens, when sal moniac is treated with most metallic substances.

Lastly, the solutions by the nitrous acid, the precipitations, and the on of caustic volatile alkali, all these means employed by opera- ns repeated each of them five or six times, have been insufficient, effect a compleat purification of nickel, and especially a compleat aration of the iron. It appears even from Mr. *Arvidsson*'s expe- ents, that the more the regulus was purified, the more hard, te- ious, and more difficultly fusible it became, and it acquired more he properties of iron. Accordingly this good chemist concludes, h reason, that the perfect purification of nickel cannot take place any means hitherto known; that the sulphur can scarcely eparated from it, by repeated calcinations and dissolutions; that arsenic is more firmly united with it, although it may be expel- by means of powder of charcoal and of nitre: that cobalt eres even more powerfully than the preceding substances, since e discovered it in some products in which it could not be ren- ed sensible by any other methods; and lastly, that the quantity of cannot be diminished but in a certain degree, since the magnet acted the buttons that were purified as much as they could

A very remarkable magnetic phenomenon happened in one of *Arvidsson*'s experiments, which is, that a regulus purified by phur, and brought by repeated calcinations and reductions to be ost as ductile and refractory as pure iron, had acquired in these rations such a magnetism, that it was not only very capable of be- attracted by the magnet, but was really become a magnet itself, se parts mutually attracted each other.

The very probable conclusion that Mr. *Arvidsson* draws from his rious examination of nickel, is that this metallic matter is no- g but iron in a particular state, by means of which it differs from other kinds of iron. He thinks that this metal is susceptible of erent modifications, which appear to make so many kinds of als. According to this chemist, cobalt itself, the load-stone, the regulus of the black load-stone are nothing else but nickel, modifications of iron. He supports his opinion upon reasons so sentaneous with many chemical facts well ascertained, that I l here transcribe, from the French translation of his memoir, at he says on the subject.

" We know in general, says Mr. *Arvidsson*, that the qualities of ron vary in a singular manner, on account of the different quan- ities of phlogiston that it contains. How many kinds of iron and teel there are! And we ought not to forget that cobalt, the load-

" stone

" stone and its regulus, as well as nickel, cannot be perfectly de-
" prived of iron, but that also they become more ductile, more at-
" tractable by the magnet, and more refractory. Lastly, iron
" exhibits the different colours which these metallic matters acquire,
" either in the dry, or in the humid way. Cobalt and the load-
" stone give a red colour to acids; the load stone shews this colour
" even in glasses. Nickel, and the load-stone, being melted with
" borax, give a hyacinthine colour. A green colour is obtained
" from nickel dissolved in acids, from its calx, from the black load-
" stone well calcined, and also from its scoria when reduced by
" means of the white flux. Lastly, cobalt gives to glass a blue
" colour, or rather a violet, and the load-stone gives a similar colour
" in fixed alkali, and nickel in volatile alkali.

" Iron presents all these varieties. When dissolved in acids, it
" communicates to them a green colour, which lasts while the me-
" tal retains a certain quantity of phlogiston, whereas they become
" yellow, red, or of a reddish-brown, according as the quantity of
" the phlogiston diminishes. It also tinges glass of a green, yellow,
" black, or red colour. If it be calcined with nitre during several
" hours, the bottom and sides of the crucible are covered with sa-
" line flowers of green, blue, or of a purple colour. This efflore-
" scence scarcely colours water, and like iron, communicates to
" glass a greenness which vanishes by cooling. Whence it appears
" that this colour which we obtained from nickel, by means of
" nitre, was chiefly produced by iron. It is to iron that the green
" colour of nephritic and serpentine stones, jaspers, clays and other
" earths is owing. It is that which tinges several blue stones and
" also several varieties of yellow and red."

All these facts added to a great number of experiments, give certainly much probability to the opinion suggested by Mr. *Arvidsson*; but we must not thence conclude that there are really several kinds of iron essentially different from each other. There is but one kind of iron, as there is but one kind of each of the other metals; nevertheless iron, as Mr. *Arvidsson* well observes, may by the greater or less quantity of phlogiston which it may contain, or by certain allays which it may contract, and from which it has not been hitherto disengaged, be presented in such states or forms that it might not be discovered, if its magnetism was not a certain mark by which it may be known.

The other metallic and mineral substances which Mr. *Arvidsson* considers as ferruginous, are probably only matters which consist of iron differently allayed and disguised. Messrs. de *Buffon* and de *Milly* think that *platina* ought to be put into this class. *Manganese*, and several other minerals, whose nature is but imperfectly known to us, will probably augment the compounds of this kind

d, if we make as accurate analyses of them as Mr. *Arvidsson* has
ne of nickel.

That no mode of inquiry might be omitted, Mr. *Arvidsson* also
ployed that of Synthesis, that is, he endeavoured to compose an
ficial nickel by combining the different substances which he had
nd from analysis to be contained in this compound and nearly in
fame proportion. But although the experiments which he
de with this view are very curious and interesting, I shall not
e an account of them in this place, lest I should extend this ar-
e to too great a length, and because they did not perfectly satisfy
expectations of the author; which will not appear surprising
hose who have been accustomed to such trials, and who know
n experience how difficult it is to imitate perfectly the combi-
ions which are made by nature.

We shall conclude this article by mentioning the properties which
. *Arvidsson* observed in the nickel that he had brought to the
atest degree of purity that he could. As to the properties of
kel as related by Mr. *Cronstedt*, they do not deserve any consider-
on, the regulus he obtained having been a very impure allay.

According to Mr. *Arvidsson*, the specific gravity of nickel is to
t of water, nearly as 9000 to 1000.

It appears that the more pure nickel is made, the more it ap-
aches to the tenacity, malleability, infusibility, and magnetism
ron: At the same time it becomes more fixed and more difficult
e calcined, and the more green its calx becomes. It is soluble
cids. The vitriolic acid attacks its calx, with which it forms a
en salt contained within ten sides, the crystals of which are simi-
to those of alum flattened and truncated at the two opposite
remities. The acid of nitre dissolves with difficulty this calx of
kel. The marine acid, and also most of the vegetable and ani-
l acids which Mr. *Arvidsson* tried, dissolved more or less easi-
nickel or its calx, and these solutions are green or inclined
re or less to this colour. Alkalies, both fixed and volatile, at-
k also this metallic matter, the fixed in small quantity; and the
ution made by fixed alkali is yellowish, while that of volatile al-
i is always blue.

Nickel, although it is almost as difficult to melt as forged iron is,
en it is purified as much as is possible, enters easily into fusion
h other metals. But Mr. *Arvidsson* confesses that the quantity of
kel which he was able to purify sufficiently for these allays, was
small to permit him to make all the requisite experiments on
s subject. In general he observes, that impure nickel cannot
tract any union with *silver*. It is principally the allay of cobalt
h nickel that resists this union. For Mr. *Arvidsson* having tried
with nickel which he had purified from cobalt, found that it
ld be easily united with silver, in equal parts, without producing
a

a great alteration in its whiteness, or [illegible] municated to borax a hyacinthine colour, [illegible]

Copper unites more difficultly with nickel; [illegible] theless forms a reddish ductile mass, from [illegible] a glass of a bloody-hyacinthine colour.

With equal parts, or even with a larger [illegible] gives a brittle mixture; in which respect [illegible]

Mr. *Arvidsson* could not amalgamate nickel [illegible] means of trituration. When well purified, [illegible] produces a brittle allay.

The hyacinthine colour, more or less inclined [illegible] calxes of nickel, especially those made by means [illegible] nicate to glass, may be weakened, or made to [illegible] lour produced by manganese may, and the most effectual means of restoring the colour is by addition of nitre.

Addition to the Article NITRE *of the* [illegible]

THE opinion of *Stahl* concerning the origin of [illegible] namely, that it is nothing but the universal [illegible] altered by combination with the phlogiston of [illegible] has been adopted by many, and among these, by Dr. [illegible] supports this opinion by several proofs and by experiments, of which an account is given in a memoir that obtained the prize of the academy of Berlin.

Several chemists, among whom is *Glauber*, have pretended that it is the marine acid that is changed into the nitrous, and have affirmed that they know the means of this transformation. But these promises have never been realized.

It is needless to relate here all the hypotheses which have been formed concerning the origin and the production of the nitrous acid, as they may be found at full length in the collection printed by order of the commissaries appointed by the academy of sciences, to adjudge the prize for the best researches on the method of making salt-petre, for the year 1782. We have reason to believe that after this prize has been adjudged, and the researches of the several competitors, as well as of the commissaries themselves, who have undertaken a very complete set of experiments on this subject, we shall be able to form more just and precise ideas than before on this important question concerning the origin of the nitrous acid.

As I have the honour to be one of the commissaries, and as I have had thereby an opportunity of knowing the memoirs which have been sent, as well as the experiments in which the academicians, who are to adjudge the prize, are engaged, I could now insert here a part of the important discoveries that will result from these researches; but as these inquiries are not yet finished, and as the

e authors and their discoveries ought to remain unknown, till the ize has been adjudged, I find myself under the necessity of being ent upon this subject.

I shall only say, that the sole matters capable of the putrefaction, nich produces nitrous acid, are the substances which compose the dies of animals and vegetables, especially the former, and which erefore seem to deserve the preference. Nevertheless, a consider-on of some importance teaches us not to exclude vegetables in the king of nitre. For experience shews that the nitre which results m the putrefaction of substances that are purely animal, is no-ng but a salt-petre with an earthy basis, to which it is necessary add a basis of fixed alkali in the subsequent operations, to trans-m it into a crystallizable salt-petre, fit for the purposes for which s used; whereas the nitre to the production of which the putre-tion of vegetable matters has concurred, is found to be furnished turally with the quantity of fixed alkali that is necessary, in ler to make good salt-petre. It appears then, that the mixtures st fit for the production of salt-petre, are those which contain rly as much vegetable as animal matters.

But it is not sufficient merely to accumulate these putrescible tters in large masses and to let them remain, in order that nitre uld be produced. If that were sufficient, the matter of houses office ought to contain an enormous quantity of nitrous acid. t this matter, however old, is not found to contain any, when it aken out of the pits. The reason is, that the putrefaction is not npleated. It frequently happens, that this matter, although 50, , or even a hundred years old, is found to have as fetid a smell, en taken out, as if it were only three or four years old. The se of this want of compleat putrefaction can be nothing else n the want of air. The event is very different, when these tters, or any others susceptible of putrefaction, are divided and ributed in porous earths which are in contact with air. The trefaction and total decomposition which then follow, happen much more speedily, as the putrescible matters are dispersed a-ng the porous earths in less quantity, and are therefore so much re exposed to the immediate contact of the air. Accordingly it observed, that the earths of this kind which are mixed with, mall quantity only of putrescible matter, are those which furnish t-petre most quickly and most abundantly; and this is a circum-nce which ought to be much attended to in the construction of re-beds.

For the same reason, the porous, friable, and aerial earths, as careous earths, are of all the most favourable to the production of re. It is a fact, that a small quantity of putrescible matter, as ventieth, for instance, being distributed in an earth of this nature, n, with the other circumstances necessary to putrefaction, be so

 totally

totally decomposed, that in one year no degree of fetid smell shall remain, and that salt-petre may be then extracted from the mixture.

But as the quantity of salt-petre will depend on the quantity of putrescible matter that has been totally decomposed, and as the conditions necessary to putrefaction are well known, it is easy to deduce from thence the best methods of producing in putrescible mixtures, the quickest or the most copious nitrification that is possible.

These conditions are in general the same as those of all kinds of fermentative movements, that is to say, a continued heat from 25 to 30 degrees of *Reaumur's* thermometer, an habitual moisture, and above all, the free access and contact of air, in order to complete the putrefaction. To these circumstances must be added the requisite shelter, to prevent the rain from washing away the putrescible matter, or the nitre as soon as it is formed. I make not the least doubt that nitre-beds may be formed, which may yield much larger quantities of nitre, than any that have been yet made.

Upon these principles, it follows that as earths do not serve to any purpose but to divide the putrescible matters, and to accelerate the completion of the putrefaction, by facilitating the access and the contact of the air, they are not necessary to the process of making nitre; and other matters less weighty and bulky, may perhaps be substituted in their place to advantage; such as small sticks, fagots, bark of trees, all which might be strongly impregnated with the most common animal matters as excrements, and accumulated in heaps that are very considerable, and at the same time permeable by the air. It would be easy to keep up in these heaps a proper degree of moisture, either by watering them or by placing them in humid subterranean places. The laborious manœuvre of stirring and exposing to the air all the surfaces of the putrescible matters, would in this case be unnecessary. The most expensive circumstance would be to keep up an habitual heat of about 30 degrees of *Reaumur's* thermometer. If the operation was required to go on speedily, stoves would be necessary in this climate, during eight months of the year: But the greater produce would perhaps amply compensate this expence. Moreover, although all appearances are in favour of the success of this kind of mixtures treated in the manner I have mentioned, I cannot absolutely warrant its success, because I have not yet made the experiment of it, nor do I know that it has been made by any other person.

But to return to what has been long known concerning nitrous acid, I shall observe that it is not found disengaged, but as fast as it is formed, it combines with such matters as it can dissolve, and as are found within its reach. Thus it is sometimes found united with a fixed alkali and forms consequently ordinary nitre, such as the nitre found in plants or formed by the putrefaction of vegetables.

es. But it is most frequently combined with absorbent earths, cause it generally meets with these earths in the places where it formed in greatest plenty. It is therefore commonly found under e form of *nitre with earthy basis*.

There are some earths in which a considerable quantity of salt-tre is habitually formed, well crystallized and with a basis of fixed cali, and may be obtained by a simple lixivium, without any addin of ashes or of fixed alkali. The Duke of *Rochefoucault* observed great deal of this kind of earth forming a stratum of several lines in ckness, upon the surface of the rocks of chalk, in the environs of *Rocheguyon*. A remarkable circumstance is that the nitre is never und with a basis of fixed alkali, but in the neighbourhood of inhaed places, as Mr. *Lavoisier* observes, who also visited these rocks: ereas the nitre that the *Duke of Rochefoucault* procured from ese chalks whether on the surface, or at considerable depths, in ces at a distance from any houses, was constantly found to have basis of calcareous earth. There is reason to hope, that the *Duke Rochefoucault*, M. *Bucquet* who was also concerned in these obserions, and M. *Lavoisier*, will publish the researches which they ve made upon these earths. They cannot fail of being very eresting.

According to Mr. *Bowles*, in his *Introduction to the Natural History l Geography of Spain*, the nitre which is obtained in large quanies in several parts of that kingdom, has also a basis of fixed kali. But far from concluding from thence, against all probaby, and even against the best attested facts, (as Mr. *Bowles* does) at the fixed alkali of this salt-petre, as well as its acid, are habially formed without the acid of animals or vegetables; no chemist ll make any other deduction from this fact, than, that as in hot mates the putrefaction of vegetables happens in less time than in ld climates, those plants, from whose decomposition the nitrous id is formed, do also yield a portion of the fixed alkali that is neflary to constitute it perfect nitre. I say a portion, because it is obable, that in these lixiviums of nitrous earths in Spain, there also a considerable quantity of salt-petre with earthy basis, which lost, because no ashes nor fixed alkali are mixed with it. This nnot be ascertained from Mr. *Bowles*'s account, because he has ot made any experiments on this matter.

Another fact pretty remarkable is, that certain kinds of ashes hich contain little or no fixed alkali, such as the ashes of the amarisk, do however, when added to nitrous lixiviums, contribute much to the production of a salt-petre with basis of fixed alkali, the ashes that are the most rich in alkali. This fact is certain, nd has been verified by M. *Tronson du Coudray*, an officer of the tillery, Correspondent of the Academy of Sciences, and distinuished by his knowledge in chemistry. This would seem to prove

that the addition of fixed alkali is unnecessary in the lixiviation of nitrous earths. But this is only a deceitful appearance. The matter may be thus explained. There are in fact some kinds of vegetables whose ashes contain little or no disengaged fixed alkali. But they are nevertheless filled with vitriolic neutral salts with basis of fixed alkali; and it has been ascertained by several chemists and especially by M. *Lavoisier* and myself, that nitre with basis of calcareous earth and neutral vitriolic sal s with basis of fixed alkali do mutually decompose each other by means of a double affinity; that is to say, that the vitriolic acid of vitriolated tartar, or of Glauber's salt, is transferred to the calcareous earth of the nitre with earthy basis, with which it forms a selenites that precipitates; while on the other side, the nitrous acid unites with the fixed alkali thus abandoned by the vitriolic acid, and thus becomes a salt-petre with basis of fixed alkali, no less perfect and crystallisable, than if to the nitrous lixivium had been added the quantity of disengaged fixed alkali that is necessary to the total decomposition of all the nitre with earthy basis that it contained.

We may easily understand, from what has been said concerning the generation of nitre, that the quantity of this salt ought to be very variable in the earth in which it is formed. In general, it is not very considerable. There are some of these earths which do not yield more than two or three ounces per hundred weight; and the richest of them, which are composed of the rubbish of old houses, do not yield more than one pound. But there is reason to believe that by artificial nitre-beds judiciously formed, that is, by a concurrence of all the circumstances which experience shews to be necessary to the production of nitrous acid, especially the access of air, shelter from rain, the most favourable degrees of heat and moisture, this production might be considerably hastened and augmented.

Addition to the Article PHLOGISTON *of the former Edition.*

THOSE who are acquainted with the detail of the phenomena of chemical operations, and who possess the genius of the science, that is the faculty of perceiving and comparing the relations which these phenomena have to each other, are well convinced that the most pure and simple matter of fire, notwithstanding its extreme mobility, may be combined with even the most fixed bodies; that it loses by means of this combination, the rapid motion and other properties which characterise it; that this igneous principle communicates to the compounds into which it enters as a constituent part, the characters of combustible and inflammable bodies; that the combustion of these bodies and all the effects which accompany it, are produced by the disengaging of the fire, which passes

passes from the state of combination and fixation to that of liberty, and to its natural mobility; that this fire, which when combined and fixed acquires the name of phlogiston, may like other chemical agents, pass from one combination into another without becoming disengaged fire, and consequently without producing the phenomena of combustion: so that the combustible body which transmits it remains no longer combustible after it has thus parted with it, while the new body with which it combines becomes combustible, although it was not so before its union with the igneous principle. Moreover, all this theory, founded on facts as numerous as incontestable, contains nothing that seems obscure to those who know the facts, and who have been accustomed to see them. It is not so however with some other persons, who although they have never been at the trouble to understand or even to read the good books that have been published on chemistry since the revival of the sciences, that is to say, from *Stahl* inclusively, do not however hesitate to pass their judgment on them. The theory of phlogiston seems to be reprobated by them because they do not understand it, nor have the least idea of the proofs on which it is founded. A substance supposed to be material, although it cannot be confined in a pure and disengaged state in a bottle, as acids, alkalies, and other chemical agents may, appears to them to be a chimerical idea, which has no existence but in the imagination of chemists, and invented to explain well or ill a number of facts, and of obscure and embarrassing phenomena.

The most prudent conduct would be to leave these persons in their opinion without making new efforts to clear up this matter. Nevertheless, as chemistry must gain by being better and more extensively known than it is, I shall here add some considerations relating to phlogiston, the idea of which was suggested by what I have said concerning the nature of fire. The opinion which I have adopted in the article on FIRE consists in acknowledging no other igneous substance than the matter of light, and in considering heat only as a movement of oscillation or vibration, of which the aggregant and constituent parts of any bodies are susceptible, when they are shook by the impulse either of light, or of any other matter in motion. If this opinion be well founded, it necessarily follows, that heat not being a peculiar matter, but only a modification, a mode of existing of which all kinds of matter are susceptible, cannot any more than motion, enter into any combination, nor be fixed in any compound as a principle or constituent part. Accordingly *phlogiston*, or the combined fire of chemists, is not *heat*, or any thing relative thereto. But as combustible bodies produce in their combustion all the phenomena of fire, the igneous principle, to which they owe this property, can therefore be nothing else than the matter of light, which, when it is disengaged from the fetters of com-

bination, produces not only the phenomena peculiar to it, but also heat, or the movement of vibration of the particles of bodies in which heat essentially consists.

It follows from thence that the names of the *igneous principle, combined fire, fixed fire, inflammable principle*, or lastly, that of *phlogiston*, do express nothing else than the matter of light considered as fixt in mixts as one of their constituent parts. All the difficulty and obscurity which those who have not read and understood the works of the best modern chemists have found in the theory of phlogiston, proceed solely from this, that they have not had a clear idea of the nature of fire, and from considering heat as the same thing as fire, whereas it is only one of the effects of fire, and an effect which even is not peculiar to it, but which may be produced by any other matter, provided it be animated with a sufficient quantity of intestine motion.

Phlogiston is then nothing else but the peculiar substance of light fixed mediately or immediately in a great many compounds, of which it is one of the principles, and deprived, while in this state of fixation, of its mobility, and of the other properties which distinguish it when it is disengaged.

Light being acknowledged a material substance, whose motion, elasticity, refrangibility, and reflexibility are known, which may be directed, turned aside, reflected, concentrated, dispersed, &c. which may be even decomposed and recomposed, there is no more difficulty in conceiving that it unites and combines with any other kind of matter, than in comprehending that air, water, and earth are susceptible of these unions; and nobody has ever suggested a doubt that the air, water, and earth that are obtained in the chemical analysis of mixts, were combined in these mixts before their decomposition. Why should not the same take place with regard to light, a substance which is indeed possessed of a greater degree of mobility, but is no less material than water, air, and earth? Can there be any kind of matter that is not subjected to attraction, or to the general tendency of the parts of matter to each other, and that is consequently capable of contracting all imaginable unions, when nothing resists these unions? Can a matter such as light, with the curious properties of which, not only chemists but persons the least conversant in natural philosophy are acquainted, be considered as an imaginary being? When it is demonstrated by the most numerous and best ascertained facts, that this substance, to which none of the properties of matter are wanting, is really combined as a constituent part in a great many compound bodies, and particularly in combustible bodies, shall we not be permitted, to denote it by a particular name, such as that of *phlogiston*, to distinguish the portion of light which is in this state of combination and fixation, from the portion of the same matter, which not being combined, possesses all

the mobility that characterises it in its state of liberty? Chemists convinced by multiplied and incontestable experiments, that fat, resins, bitumens, coal, metals, and, in a word, all kinds of combustible bodies, do daily form with the vitriolic acid, which is not combustible, a combustible compound called *sulphur*; and that the combustible bodies employed in this combination, lose their combustibility in proportion as they contribute to the production of a greater quantity of sulphur; have from thence concluded, that in all combustible bodies there is a matter combined, a principle to which these bodies owe their combustibility: and that it is this same matter which quits them in order to unite with the vitriolic acid with which it forms the new combustible compound.

The same chemists, after having subjected to all the imaginable proofs the sulphur which they produced in the different combinations above-mentioned, and after having ascertained with the clearest evidence that this sulphur was always perfectly the same, and absolutely *identical*, of whatever nature the inflammable body was which furnished the phlogiston, have thence concluded, that as the vitriolic acid of this compound was constant, nothing could occasion any difference but the inflammable principle; and as no difference existed in this principle, or in the sulphur thus formed, therefore this phlogiston was itself an invariable substance, always the same, lastly, quite *identical* in any combustible bodies.

This truth has been confirmed by an infinite number of other facts as certain and as decisive as the artificial composition of sulphur, and especially by the reduction of all metallic calxes. For most metals when exposed to the action of fire with the free contact of air, that is to say, with the conditions necessary to the combustion of combustible bodies, lose more or less completely their metallic appearance and properties. Some of them even burn with a very sensible flame. From these facts chemists have concluded that these compounds contained the principle of inflammability or phlogiston. They found that the earths or ashes remaining after these combustions might be again formed into metal whenever any combustible body containing phlogiston, and capable of restoring to them what they had lost was applied to them; that this combustible body employed in the reduction of metallic earths, lost its combustibility in proportion as it communicated this property to the earths thus reduced into metal. They concluded from these facts that the phlogiston had passed from the combustible bodies into the metallic compounds. Lastly, they demonstrated by the most simple and most certain experiments, that the earth of any metal, such as that of lead, for instance, never formed any other metal than lead by its combination with phlogiston; and that of whatever kind the combustible body was, the phlogiston of which was applied to reduce this calx of lead, whether it was oil, resin, fat, wood, coal, or even

some other metal, there resulted from all these combinations a lead always exactly the same without the least sensible difference. From these facts they have concluded that the principle of inflammability was a constant being, always the same, and always similar to itself, in a word, an identical being throughout all nature, in the same manner as air, water, gold, and many other bodies more or less simple or compounded, but constant, identical and invariable each in its kind. If this be not a legitimate conclusion, a conclusion which necessarily follows facts; if we are not allowed to say that a globule of pure gold is entirely similar and identical with another globule of pure gold; that a drop of pure water is the same kind of matter as another drop of the same water; that a molecule of light undecomposed is not different from another molecule of the same light; it must be acknowledged that all reasoning must cease, not only in chemistry, but also in every other kind of science or knowledge.

I have already made most of these remarks in many places of the former edition of this work, and even in the article *phlogiston*; I must ask pardon of the attentive and intelligent readers for this repitition. But it will be acknowledged that I am obliged to it, by the following passage in a work printed in 1774.* "The same "phlogiston of chemists (a being of *their method*, rather than of "Nature) is not a *simple* and identical principle, as they pretend. "It is a compound, the produce of an allay, the result of the combi"nation of the two elements *air* and *fire*, fixed in bodies. With"out therefore entering into an examination of the *obscure* and in"complete ideas which the consideration of this *precarious* being "could suggest, let us consider our four real elements, to which "chemists, with all their new principles, will be always obliged "ultimately to recur, &c."

Here is a decision, which considering whence it comes, would certainly be a severe censure upon all those who have engaged in chemistry, since the renovation of the sciences, if it were merited, and had been pronounced after a sufficient knowledge of the [illegible]tion had been acquired.

I know very well that it cannot make any impression upon those who give themselves the trouble seriously to study chemistry, and understand truly this science, and that in this respect, it were superfluous to justify it. But I know also that the number of true chemists is very small, while that of the readers of the works of the illustrious author whom I have quoted is very great, and it is certain, that these latter, who compose almost the whole of the public, and who know the name only of chemistry, must receive their

* Supplement to Natural History by Mr. *Buffon*.

..n this celebrated writer, whose authority is of so great weight; ...l as an unfavourable impression must necessarily be the result, ...ich may be so much the more hurtful to the progress of science, ...t would be more general, I believe that it is indispensibly neces... ...y to justify our modern chemistry from imputations so little ...rited.

I must therefore beg leave of the readers, and even of the illus... ...ous and severe censurer to whom I reply, to make some short ...lections, which will have no other end but to lay before him the ...th, and to inspire him with sentiments more favourable.

The phlogiston of chemists is represented as a *being of their me...d, rather than of nature*. Upon this we shall observe that the ...m *method* which used to have a favourable signification, must be ...e taken in a different sense, since whatever can be called *method* ...proscribed in the works of this writer; but we must remark, that ...atever idea can be annexed to a doctrine that is denoted by the ...pression *method*, it certainly is not applicable to the doctrines of ... chemists in any age. The pretended *method* of chemists does ...erefore exist only in imagination. For if any fault is to be found ...th them it must be on account of their want of method. They ...ver were before blamed for having any. Whoever would be at ... trouble to read their works, would perceive that they contain ...thing more methodical than the works of the philosopher who ...us generally blames all kinds of method. Secondly, it is said, ...t phlogiston *is not a simple identical principle, as chemists have re...sented*. In this charge we find an allay of truth with falsehood, ...ich ought to be parted. It is true that chemists do represent ...logiston as an identical principle, as the same being, or same kind ... matter, whatever be the nature of the compound bodies in which ...s combined. And if there be any truth demonstrated in natural ...ilosophy, this is certainly one, as appears from what we have ...d above. But it is absolutely contrary to truth that chemists ...ve decided that phlogiston is a simple being. They declare that ...ey have no certainty of the absolute simplicity of air, water, or ...en fire, and they have formally explained themselves on this ...ad. How then should they attribute simplicity to phlogiston ...hich can be nothing else but pure fire, or fire combined with ...me particular matter necessary to fix it, with some intermediate ...bstance by which it may be rendered capable of combining with ...her substances; and in this case it would evidently be a secondary ...inciple, or a compound body. However weak they may be sup...posed to be, this absurdity exceeds the bounds of probability. If ...y one will be at the trouble to read what is said on this subject in ...is article, he will see that the opinion maintained is that the ...inciple of inflammability can be nothing but either the most ...mple and pure matter of fire itself, or else this same matter com-

bined

bined with some particular substance which is always the same. Chemists have thus left undecided the question concerning the absolute simplicity of the principle of inflammability: but as it appears, this celebrated author has not been sensible of their conduct in this respect. He himself has however taken upon him to decide the question. He has pronounced that the principle of inflammability, *the true phlogiston of nature is a compound, the result of combining two elements, air and fire, fixed in bodies.*

Although nobody is more sensible than I am of the value of the ideas of this illustrious naturalist, this opinion appears so contrary to the best ascertained chemical facts, that I find myself obliged to explain the reasons that prevent me from adopting it. I am going then to refute the opinion of a great man whom I honour. This reflection has almost stopped my pen. But can I fear that I shall trespass upon the respect due to him, if I do only use that liberty of sentiment in matters of science, of which he so well knows the rights and advantages, and which can never fail to be regulated by the rules of good-breeding, when it has no other motive than the love of truth.

Let us observe first, that if it were proved that the element of fire cannot be fixed in bodies, while it is pure and simple; that it necessarily required to be combined with another element; that this element were air; in a word, that phlogiston were a compound of air and fire; as these two substances are constant beings, each in its kind, it would follow, that the compound which they would form by their union, namely phlogiston, would be also a constant and identical being throughout all nature, and that consequently, the chemists who have represented it as identical, not from reasonings, but from a multitude of conclusive facts, of which I have made mention, would not have merited the reproach that has been thrown on them.

But this is not the principal object here. It is necessary to know what the matter of fire is, to decide what property it is known to have, which disqualifies it from entering as a pure and simple principle into the composition of other bodies, as all the other kinds of matter do; to determine whether there be only one substance capable of binding this matter of fire, and of being employed as a necessary intermediate substance to fix it in the combination of compounds. We ought further to determine if there be any of the facts known in chemistry which prove that this substance, which is thus capable of forming phlogiston by its union with the matter of fire, is *air*.

Lastly we ought to examine if all the chemical facts do not on the contrary unite to prove that the matter of fire has not occasion of any intermediate substance, or of any allay, in order to be fixed in different compounds, as one of their constituent parts, and particularly

ticularly that air does not enter into the composition of combustible bodies which contain more fixed fire or phlogiston than any other bodies. I shall make upon these different subjects the following remarks.

First, none of the properties of fire hitherto known, proves that this element is any thing but the proper substance of light. They farther prove that there is nothing material in fire but the pure substance of light; and that heat is only a modification, a particular state, which is not peculiar to the matter of fire, but of which all bodies as well as light are susceptible. This proposition I believe I have proved at the article FIRE.

Secondly, I acknowledge, that before I had this idea of the nature of fire, I believed with the greatest number of Natural Philosophers, that *heat* was a real substance, a matter of a particular nature, capable of acting, as we see that fire acts upon all bodies; that in a word, heat was the true matter of fire, the most simple and pure igneous matter; and that in this false idea, not being able to conceive how this pretended matter, which penetrates all bodies without being ever fixed in any of them, could nevertheless become the principle of the inflammability of bodies, I imagined that there might be in nature a kind of matter, entirely unknown to us, which alone might have the property of uniting directly with fire, and which having thus once fixed it, was the necessary intermediate substance by which it might enter as a constituent part into the composition of combustible bodies. This, I admit, was only a conjecture, which even departed from the opinions of *Stahl*, and was solely intended to explain an unintelligible fact, of which that chemist had left no explanation. I confess further, that this conjecture on the nature of phlogiston, having been imagined merely to explain a fact which I then believed to be true, but which is not so, namely, that heat is a substance, which in certain cases and by means of some other intermediate substance combines in bodies, ought to appear so much more obscure, so much more vague, and destitute of proofs, as this substance that is supposed to be the necessary connecting matter by which fire is converted into phlogiston, was not either known, or ascertained, nor even could be assigned.

It is probable that the illustrious author of the *Introduction to the Natural History of Minerals*, found himself no less embarrassed than I was; but being bolder, and not chusing to leave any thing undecided on so important a subject, he attempted to dissipate all obscurity from it, by assigning the matter which is to serve to connect fire, so that it may be able to form the fixable fire or phlogiston; and it is *air* that he has chosen to make along with fire, not the phlogiston of chemists, but his own phlogiston, which he calls that of nature.

Our

Our opinion then did not differ but in this respect, that I did not determine what the substance was which could serve as an intermediate substance to fire, in the formation of phlogiston, and that he did determine that substance. But I ought to remark, that it was only upon the supposition that we can demonstrate that the matter of fire alone was not capable of being fixed in bodies, that I dared to imagine that an intermediate substance might be necessary, without presuming to determine what this substance could be. But if it be proved, as I believe it now is, that the most simple and pure matter of fire, which is nothing but *light*, is capable, like any other kind of matter, of combining directly in compound bodies, it is manifest, that its previous union with air or with any other particular matter, is entirely useless and supposed without any necessity. I must then abide by my first proposition, which fundamentally is the same as that of *Stahl*, namely, that phlogiston is nothing else than the most simple and pure matter of fire fixed directly, as a component part, in the combination of many bodies, and especially in that of combustible bodies. As then the pure matter of fire is nothing but light; and as none of the properties of light indicate that it is not as capable of being fixed as any other kind of matter, nothing here appears indeterminate, obscure, precarious, and we ought both of us, the illustrious author whose opinion I contest, and myself, to abandon, with a good grace, he his mixture of air with fire, and I my combination of fire with some unknown matter, to which, however, I had no resource, but conditionally; for want (I confess) of having sufficiently reflected on the nature and properties of fire, and from my having confounded them with heat. In fact, if we have occasion only to consider *light* as the sole matter of fire fixable in bodies, in order to explain all the phenomena of combustible bodies, why should we suppose any other matter with which it ought to be combined in order to render it *fixed fire*, *phlogiston*, or the principle of the combustibility of bodies? And although even this supposition were as necessary, as it appears to be useless and unsupported by proofs, what motive can we have to prefer *air* to all kinds of matter, in order to compose with fire, the principle of inflammability, or the true phlogiston of nature. Let me reflect ever so much on this subject, I cannot discover any reason of this preference given to air; and not only I do not believe that any plausible reason can be alledged, but on the contrary, it appears to me to be proved by facts, by the phenomena of *combustion*, and of *phlogistication*, that air and fire do always reciprocally exclude each other from combining in the same compounds; and that these two elements do constantly precipitate each other in these two great operations, to which every thing concerning the union of the matter of fire and its disengagement may be reduced.

The

The operation in which the igneous principle is separated in the oſt ſenſible and expeditious manner, is combuſtion. But it is monſtrated by facts, firſt, that no kind of combuſtion can be ade without the concurrence and contact of external air: ſecond- that in proportion as the combuſtion proceeds, there is a dimi- tion and abſorption of the air that has concurred to this com- ſtion: and thirdly, that the part of the combuſtible body which nains after the burning of it, contains as much air combined and ed, as there had been air employed in the combuſtion of that dy. Is it not manifeſt from theſe eſſential circumſtances of com- ſtion, that the phlogiſton or fire fixed in the combuſtible body is parated from it merely by the action of the air, which takes the ice of the phlogiſton, as ſoon as this principle is diſengaged and comes fire, and conſequently, that air is the decompoſing me- im, or true precipitant of the matter of fire?

The operation in which the igneous principle is combined in the oſt ſenſible and expeditious manner, is the reduction of the rths or aſhes of metals, into a metallic ſtate. But it is now de- onſtrated, by the moſt deciſive experiments, that theſe metallic rths or aſhes, which are the reſiduums of a true combuſtion of etals, are, as well as the aſhes of all other combuſtible bodies, arged with all the air that had ſerved to the diſengagement of their logiſton; that their augmentation of weight is owing to this r which is thus combined in place of the diſengaged matter of re; and laſtly that they can never be re-eſtabliſhed in their me- llic ſtate, by reſtoring to them the matter of fire, unleſs the air at was fixed by means of, and during, the combuſtion, be diſen- aged in proportion as the matter of fire is re-combined with them nd reſumes its former place by this reduction, which is really the ppoſite operation to combuſtion. And as no metallic reduction an take place without the concurrence and contact of the matter f fire, and as a diſengagement of air and a proportionable dimi- ution of the weight of the metallic calxes in every reduction actu- lly happen; is it not evident, that the matter of fire does in this aſe ſeparate the air combined in the aſhes of the metal, and re- ume its place, while it is thus again combined, and conſequently ecome the decompoſing medium of the *aerial earthy* mixture, which t changes and reduces, by means of its own union, into another *gneous earthy* mixture, that is to ſay, into metal: and laſtly, from ll theſe facts, now rendered inconteſtable, ought we not to con- lude, that, ſo far from the matter of fire wanting the concurrence nd mixture of air in order to fix it in bodies, and to become the phlogiſton of nature, theſe two elements have a kind of incompati- bility, ſince they expel each other reciprocally, and ſince one of hem cannot be fixed in any body without at the ſame excluding the other?

Notwith-

Notwithstanding the force of these considerations which seem to prove evidently, that phlogiston is not and cannot be the result of a mixture of fire and air; I confess, that if we knew any facts which could prove that the principle of inflammability is nevertheless the result of such a mixture, these proofs or matters of fact, which ought to be positive and direct, ought to be preferred to those which I have alledged. If, for instance, we could not decompose any combustible body so that it should not remain in any degree combustible, without a quantity of air disengaging itself at the same time proportionable to the quantity of the matter of fire which should have been separated from it; and reciprocally, if in all the operations, in which the matter of fire enters into a compound, it were proved, from the circumstances of these operations, that a new portion of air does also enter into the same combinations, it would be natural to conclude, that the air is an intermediate substance by which the matter of fire combines and fixes in bodies. But I maintain, that no such fact can be adduced; and I appeal to the testimony of all those who are acquainted with the detail of chemical operations.

For, let any combustible body, (excepting sur-compounds, such as wood, bones, &c.) be subjected to any analysis or decomposition, without excepting even combustion, we shall never obtain any air in these decompositions. The reason, why sur compounds ought to be excepted, is, that their analysis shews, that besides their constituent oily part, to which alone they owe their inflammability, they contain also other proximate principles, from which a great quantity of air may be obtained. But these latter principles, which are chiefly of an earthy nature, do not possess in themselves any combustible quality. We must not then class among combustible bodies, any but those which in fact are so of themselves, that is to say, those in which the matter of fire is really a constituent part, and which cannot be entirely decomposed, without the igneous principle being disengaged from their combination, either by the combustion which renders it totally free, or by the change which makes it pass into a new compound of another kind: in both cases, what remains of the combustible body that has been decomposed by the separation of the phlogiston, ought to be, and is, in fact, incombustible; but with this difference, that when it happens in consequence of a change produced, the body in which the matter of fire combines from being incombustible, is rendered by this new union, combustible; which effect ought necessarily to take place, and does very sensibly happen in the artificial composition of sulphur, in metallic reductions; in a word, in all operations where there happens a similar translation of the principle of inflammability from one compound into another.

The

These unequivocal characters of the only compounds that ought be considered as combustible, being determined, I resume my oposition, and I say, that we cannot find any such combustible ody from which any portion of air can be obtained by any means. The only bodies really inflammable that we know in the vegeta-e and animal kingdoms, are *oils*, *resins*, *fat*, *ardent spirits*, and *hers*; and when vegetables and animals are half decomposed by e action of fire, without the concurrence of air, by distillation in ose vessels, that is to say, without combustion, the only inflamma-e matters that are obtained, are empyreumatic oils and charcoal.

In the *mineral* kingdom, which comprehends none but unorga-zed compounds, we do not know any inflammable substances but *tumens*, or rather their *oils*, *sulphur*, and *metals*.

But I say, to whatever analytic operations all these combustible dies be subjected, no air is ever obtained. This fact is well own to chemists who are daily employing these bodies in their erations, and I have myself verified this fact upon most combus-ble substances. I therefore think myself entitled to conclude that l the known chemical facts concur in proving that the principle of mbustibility is not a compound resulting from the mixture of air d fire.

But since I am engaged in this discussion, and as it seems expe-ent to clear up the theory of phlogiston, which seems so obscure to any persons, notwithstanding what has been said on this subject the most profound chemists who have written, I will add a few nsiderations to endeavour to throw more light upon it.

When I mention my reasons for believing that phlogiston is not e result of fire and air, I am far from wishing to have it under-ood, that these two elements cannot unite and form together par-cular compounds. Such an assertion would be an evident contra-iction to what I have said. I have frequently maintained, and I ere repeat it, that all the parts of matter, whatever difference there ay be amongst them, are essentially capable of combining toge-her, that they even all tend to this union; and that it is constant-y effected when it is not resisted by any particular obstacle: and it llows from thence, that air, and fire or light, being two material bstances, may and ought to unite and combine together whenever hey meet in circumstances favourable to this union; and as Na-ure has, undoubtedly, made all the possible combinations, there ught to exist some compound of air and fire.

What I have said of combustible bodies, shews sufficiently, that f such a compound exists, we ought not to look for it among those ombustible bodies which I have mentioned, although almost all hat exist in nature are comprehended among them; but one kind s known which seems to be, or to contain, a compound of air and ire, I mean to speak of *Gas*, or the *inflammable Gases*. But as this kind

kind of combustible bodies has its aggregation and several of the properties of air, we can scarcely avoid considering these gases but as compounds into which air and fire enter as constituent parts.

The nature of these gases, the examination of which is but lately begun, is not yet well known. Their inflammability is but just ascertained. We therefore cannot decide with certainty concerning their constituent parts. It is not even demonstrated, that air is one of their principles. But what is very certain, is, that they donot differ from all the other combustible compounds, in what concerns their combustibility, and that in particular they are subject to the general rule, viz. that none of these bodies can lose their inflammable principle by combustion, but by the action and intervention of pure and disengaged air. We know also that inflammable gases may transmit without combustion, their inflammable principle to other bodies, and particularly to the earths of metals. I have been a witness of the various experiments by which M. *Montigni* has ascertained this important effect; and we cannot doubt, that what remains of these gases thus decomposed by this operation, which is also an elastic fluid, is rendered as incombustible, as the residuums of all the other inflammable bodies which have lost their phlogiston by a similar translation. But, these facts, far from proving that these compounds of air and fire can enter, without being decomposed, into the composition of combustible bodies, and become their principle of inflammability, or the true phlogiston of nature, do, on the contrary, shew that these gases are nothing but mixts that may be decomposed, like all others, which owe their inflammability to the pure and simple matter of fire; and lastly, that as this same matter may be separated in its state of simplicity, without carrying off with it any portion of elastic fluid, to enter into the mixture of new compounds, there is truly but this pure matter of fire alone that can become the principle of inflammability, by being fixed in any compounds: in a word, it is the sole and true phlogiston and becomes so merely by being fixed.

Every thing then concurs to prove that the matter of fire, or rather of light, needs no intermediate substance to render it capable of combining with other bodies that are properly disposed to join and unite, as with air, water, earth, and in a word, with all kinds of matter; that particularly none of its properties shew, that it has occasion for air as an intermediate substance, but that on the contrary air is it's sole and necessary precipitant, in all those occasions where it ceases to be phlogiston, and becomes pure and disengaged matter of fire. And, I think, I may conclude from all these considerations, that as the matter of light is a one and identic substance, and does not cease to be so by being fixed and becoming phlogiston; phlogiston is also one and identic, as I have advanced; that phlogiston is as simple as the matter of light is, since it is only this same

matter

ter confidered in its ftate of fixation and combination: laftly, the true phlogifton of nature is not a variable being, a *compound, oduct of an allay*, the *refult of a combination of two elements, air and fixed in bodies*.

t would certainly be very interefting to know how, in what umftances, and with what phenomena, the matter of light or of does combine with other kinds of matter, to form the feveral po inds of which we know by experience and analyfis that it conftituent part. But by what means fhall we rife to this fub- degree of knowledge? The combination of the firft principles odies is inacceffible to our fenfes; we have not any idea of the re, of the mafs, of the hardnefs, nor of any of the other effential ities of their parts. The primary integrant molecules of air, er, earth, and even the moft compounded bodies, are as unknown s as thofe of light; we can perceive the refults of their unions, of their feparations, but the mechanifm of thefe wonderful rations is one of thofe myfteries of nature, which will probably or ever hid from us. I will therefore avoid giving conjectures n a fubject which I know is above my reach, and I will confine elf to relate the fmall number of facts that are known, which e fome relation to this matter.

everal perfons think that thofe kinds of phofphorus which ap- r luminous in the dark, after having been expofed to the fun or he light, produce their effect by imbibing light, and by retain- it during fome time. Although this opinion be not proved, nuft agree that it feems to be very probable: and if it was de- nftrated, it would prove, that light could adhere at leaft in a ain degree to bodies of different kinds.

f we expofe to the focus of a burning glafs, martial earths fuf- ently calcined not to be attracted by magnets, upon a fupport ch cannot communicate to it any inflammable principle, they not indeed reduced thereby to iron, but they are rendered ca- le of being attracted by magnets. At leaft in a great many of fe calxes differently prepared, on which I have made this expe- ent, I have not found any of them which could not be rendered able of being attracted by this method. But we know that the h of iron cannot acquire this property but when at the fame e it approaches to the ftate of iron and refumes its phlogifton; as it can receive this phlogifton only from the light, or rather as light becomes the phlogifton thus received, this feems to prove t a part of the light of the focus that thus falls upon the mar- earth fixes and combines with this earth. This effect would be bably much more fenfible, if thefe experiments were made in e veffels of glafs, as is indicated by the experiment of the re- ction of calxes of mercury without addition.

It is at present proved, that the calx of mercury called *precipitate per se*, that *red precipitate*, that *turbeth mineral*, and even all the true calxes of mercury, may be revived into fluid quickſilver, without any addition, by the application of a proper degree of heat. As this reduction as well as that of all the other metallic calxes can be effected only in proportion as theſe earths reſume the ſame quantity of the principle of inflammability which they had loſt during their reduction into the ſtate of calx, it follows that thoſe of mercury are reduced into fluid quickſilver in the experiments abovementioned, merely becauſe the matter of light which can paſs through veſſels, eſpecially when red-hot, again re-combines in a ſufficient quantity and intimately enough with the calx of mercury, to become its phlogiſton, and thereby to re-eſtabliſh it in its metallic ſtate. But a circumſtance to which it is eſſential to attend, is, that theſe reductions of mercury, without the concurrence of any other igneous principle than the matter of light, do not ſucceed but in proportion as there is no communication with air, as I have explained at the article *dephlogiſticated air*, for if the ſame degree of heat be applied in veſſels that are not perfectly cloſe, then the revival does not happen, but the calxes retain their calciform ſtate, are ſublimed and even may be fuſed into a vitreous matter, as is ſaid in the notes to the Engliſh Edition of the Dictionary of Chemiſtry,* and according to the experiment which M. *Beaume* affirms to have made. But is not this one of the facts which prove not only that phlogiſton is not a compound of air and fire, but that on the contrary, if any ſubſtance is capable of preventing the matter of fire from uniting in compounds as phlogiſton, air has certainly this property more than any other ſubſtance.

It appears from the facts that I have explained, that we begin to know ſome artificial operations, in which diſengaged fire or pure matter of light is fixed in certain bodies, and becomes their phlogiſton. Perhaps, when we obſerve more accurately and more attentively what happens in many other operations, we may diſcover more inſtances in which the ſame effect is rendered evident to our ſenſes. But all theſe particular effects are nothing in compariſon of thoſe which nature continually produces in the great. The whole ſurface of the earth is covered with an immenſe multitude of vegetables which ſpring daily and are renewed; and theſe vegetables, from which animals draw their ſole nouriſhment and the ſubſtance of their bodies, are filled with combuſtible principles. Whence proceeds the immenſe quantity of oil which they contain, and which may be obtained from them by decompoſition? It is not the earth which can furniſh it; for the earths the moſt favourable

to

* This obſervation was taken from a note in Dr. *Lewis*'s edition of *Newman's Chemiſtry*, where it is ſaid, that the calx of mercury, when expoſed to the focus of a burning glaſs, without addition, is vitrified. *Vol. I. p.* 134. *2nd edition.*

vegetation, contain but very little of it, in comparison of the nts which grow in it; it is further very easy to shew that the small ntity of oily matter contained in the earth is extraneous to it, owes its origin to decomposed vegetables and animals. This of vegetables, which becomes that of animals, and to which y thing combustible seems to owe its origin, is then essentially product of vegetation, and the entire vegetable kingdom is the t shop in which nature makes the first combinations of the mat- of fire, probably by means of their organic vital action, and by echanism entirely unknown to us. But what we begin at least know sufficiently well, are the facts which prove the great in- nce of the pure matter of light in vegetation.

l the world knows that plants, even in the best ground, exposed ir and to the degrees of heat that are most favourable to their wth, do nevertheless languish, are discoloured, become long, , and feeble, do either bear fruit and flower imperfectly, or at all, when they are not in immediate contact with the light of sun, or at least with full day-light.

t has been constantly observed, that those plants which are en- ed in a place into which light does only come in at one side, ine themselves towards that side where the light enters, even if e towards the north.

We know that the middle part of certain plants, as cabbage and uces, of which the inner leaves are gathered together and de- ded from the light by the external leaves, remains white and ery, while the external part of these plants is of a full green much less watery. Gardeners know very well that the only ns of giving to certain esculent plants that wateryness, which ders them tender, and that whiteness which is esteemed, is to de- l them from light, which they do by tying their leaves together, y covering them with earth, straw, &c.

Lastly, *M. Mese*, has given us a very interesting series of ex- iments in the Journal of the *Abbé Rosier*. These experiments v in a more striking manner the influence which the contact of e light has upon all plants, and the necessity of this influence to etation. And as we cannot doubt but that those watery, colourless nts, which have not received much light during their growth, ld less oil in their analysis than those plants which have enjoyed benefit of the full influence of light, it is a sufficient proof that proper substance of light is fixed in all plants, and enters ma- ially into the composition of the only one of their principles that combustible, that is to say, of their oily part.

I am well inclined to believe, with most chemists, that the light omes the cause of all colours; and the opinion which Mr. *Opoix* explained in two good memoirs, inserted in the collection of *Abbé Rosier*, appears to me to be very probable. This able

 chemist

chemist has collected and compared together in a very satisfactory manner, a great number of phenomena, the total of which serves well to prove that not only light is the material principle of all colours, but also that when it becomes by being fixed, the phlogiston of bodies, it produces each kind of colour, according to the manner in which it is combined.

I shall not enter here into longer details upon these subjects. But I believe that what I have said upon them, added to the observations in Natural History, will be sufficient to convince those who will give themselves the trouble of reflecting upon these facts, that phlogiston is nothing but the pure matter of light fixed immediately in bodies, without the concurrence of any intermediate substance, and especially without the concurrence of air; that it is primarily fixed in vegetables, and that this fixation is effected by the vital organic action of these beings, whence results the composition of all oily substances; that the matter of light being once fixed and become phlogiston in the oils of vegetables, passes afterwards easily from one combination to another, and enters into many different compounds without becoming disengaged fire; so that these oils are the first origin of all the phlogistic and combustible compounds that we know. And if these ideas, which at present are only probable, were well demonstrated, it would follow that without vegetation, there would be neither oils, resins, animals, fat, coal, bitumens, sulphur, or metals, on the surface and within the earth. It is also even probable that no saline matter would exist, and that our globe would be merely a mass of simple earth, covered part or wholly with very pure water, and surrounded with air which would be no less simple and pure.

Addition to the article PHOSPHORUS *of the former edition.*

THE origin of phosphoric salt is not yet well known. Mr. *Margraaf* says, that he has obtained phosphorus by distilling wheat, mustard seed, and some other vegetable matters, and seems to be of opinion, that the phosphoric acid or salt passes from vegetables to animals. But although the greatest confidence is due to what is affirmed by this illustrious chemist, yet this extraction of phosphorus from vegetable matters has not yet been confirmed, although we have reason to believe that it has been attempted by several chemists. Some chemists are even of opinion that the phosphoric acid is produced in animals, and they consider it as the *animal acid.* It is however certain, that it may be obtained with great ease and abundance from animal matters.

Till lately, it was procured only from urine, and even from human urine alone, and not from that of other animals. But as it is not possible that the urine of all animals can have been examined, we cannot determine whether the human urine is the only one that contains it. We are indebted to Mr. *Scheele*, whom I have quoted

he article *Bones of Animals*, for an important discovery, and ich appears very proper to throw light upon the origin of the sa- matter, to which the name of *phosphoric acid* has been given. is discovery is, that this acid is contained copiously in the earth he bones of animals. We shall find at that article the processes Mr. *Scheele*, and a summary account of those experiments which e been made since, upon that matter: and I shall only add e, that the saline phosphoric matter obtained from bones by ns of the vitriolic acid, although proper for the making of sphorus, appears nevertheless to differ in some respects from acid that remains after the combustion of phosphorus, and that it is not entirely similar to the crystalline substance which *Duke of Chaulnes* obtained by distillation and by fusion in a crucible n the phosphoric salt of urine with basis of volatile alkali. These erences are not yet well ascertained; and it appears to me from at I have hitherto been able to learn, and from the comparison ich I have made on the vitreous matter obtained from bones, h that of the fusible salt of urine, which the *Duke of Chaulnes* s so obliging as to give me a specimen of, that this latter retains acidity, a deliquescence, and a solubility in water, which the mer does not possess. I am also informed by Mr. *Rouelle*, that saline phosphoric matter of bones, yields less phosphorus than matter of phosphorus itself, or than the fusible ammoniacal of urine does. There is room to believe that these differences ceed from some portion of the vitriolic acid remaining united th some earthy or selenitic matter, which combines along with saline glass during its vitrification, and diminishes in some de- ee its saline properties. *See* the articles BONES and URINE.

Addition to the Article PHOSPHORIC STONES.

BESIDES the phosphorical effects of certain stony and earthy matters which I have already mentioned, there are others hich perhaps may have some relation to these. I shall only give a mmary account of them, as the experiments on this subject have ot yet been sufficiently varied to enable us to form a just idea of e causes on which these effects depend.

It is known that *diamonds*, without any previous calcination, eing carried into the dark, after they have been exposed to the n or to strong day-light, appear luminous. They are, perhaps, ot the only stones which have this property.

Rock-crystal, *quartz*, *agates*, *siliceous stones*, and probably all the ard stones which are of the kind called *vitrifiable*, being struck r rubbed strongly one against another, in the dark, throw out uch light. All kinds of *glass* and *porcelain* have the same effect. This light does not consist in sparks that are darted outwardly like hose produced by the collision of these substances with steel, but

in a flash of light which illuminates suddenly all the internal part of these bodies, if it is produced by percussion, and which is permanent, if it is produced by the continued friction of a mill-stone in motion. Is this an effect of electricity? This cannot be decided but by other experiments. I am however inclined to believe that this light is neither the electric matter, nor the phlogiston disengaged from these bodies, but only that which is universally diffused, which is not visible in the dark, because it is not darted towards our eyes, but which becomes very sensible to us, when it is thus darted by the vibratory motion excited by percussion in the infinitely small parts of these hard transparent bodies, and which thus do only become luminous, because they begin to be heated. *See* what I have said on this subject concerning the nature and effects of heat at the article FIRE. In the great cold of 16 degrees in January 1776, I struck strongly against each other two pieces of ice which had been frozen in the open air. But although this ice was very hard, and had been exposed during a long time to the intense cold, I did not perceive any light. I nevertheless think it probable that it would be luminous, if it could acquire a greater degree of hardness by as much more intense cold, such as that which is necessary to the congelation of mercury.

Several *spars*, and particularly the *heavy spar* called by Mineralogists, *vitreous spar*, *sparry fluor*, *false emerald*, that from which Mr. *Scheele* has obtained the *acid of spar*, when broke into small pieces, and spread upon a very hot plate of iron, appear to be very luminous in the dark, and each parcel of these spars resembles a fine star, or a piece of luminous phosphorus.

This effect is however not peculiar to spars. Mr. *Lavoisier* has lately communicated to the Academy the observation which he has made upon a kind of chalk that possessed this property in a very sensible manner. Since that, it has been found not only by Mr. *Lavoisier*, but also by others, that a great number of calcareous earths had the same property, and even that none have been tried without producing this effect. Hence it is probably common to all earths of this kind, but probably some of them give a more lasting and intense light than others. For this light soon becomes extinct, although the plate of iron on which it is placed be kept hot. I have made some experiments on this subject, of which the following are the results.

The *calcareous earth* which contains all its animal matter, which has undergone no alteration, nor destruction by a long continuance in the earth, as it is in fresh oyster-shells, merely washed, dried and pounded, becomes luminous, when put upon a plate of hot iron. But its light appeared to me fainter than what was produced by the chalk of Bourgival.

The

The *magnesia of Epsom salt* uncalcined yielded a pretty good and lurable light. The same earth when calcined produced a light hat was weak and not durable.

The *earth of the bones of animals*, uncalcined, precipitated from ts solution in the nitrous acid, well washed and well dried, gave a iner and more durable light than that of the uncalcined magnesia.

The *quartzose pebbles* of the Loire, uncalcined, being pounded, gave a weak and not durable light.

The *earth of alum*, precipitated by a fixed alkali, well washed nd well dried, uncalcined, exhibited a very fine and very durable ight.

Lastly, what is singular, *vitriolated tartar*, powdered and put on heated plate of iron, gave a phosphoric light as intense and durable s that produced by the chalk.

These experiments were made in cold dry weather, such as is ery favourable to electricity, on the 18th and 19th of February, 777, during the night. I repeated them on the 20th of that nonth, when the air was become mild and moist, but did not perceive any difference in the results.

They were also made upon an iron shovel, which I had made ed-hot and left to cool till it was no longer visible in the dark, fter which I placed on it the matters subjected to experiment. I ubstituted a piece of poreclain in place of the iron, and the effects vere the same.

I have since made some trials of the same kind on several other natters of a very different nature, in hopes that by multiplying them, he cause of this phenomenon might be discovered. But probably a nuch greater number is required for this purpose. I have only seen hat *quick-lime slaked in the air*, and the kind of *talk* that is known inder the improper name of *chalk of* Briançon gave a light nearly qual to that of ordinary chalk; that *gypsum* or *plaster* became less uminous than chalk; that *mild fixed alkali* was infinitely little uminous; that *black flints*, calcined to whiteness, were much more o; that *diaphoretic antimony*, *putty* or *calx of tin*, washed *colcothar*, *mery* and several *ferruginous sands*, that were shining, magnetic and not sulphureous, being tried upon a heated plate of iron, gave no ight; that *luna cornea* and *white arsenic* placed upon a dish of baked earth, heated to the proper degree, gave little, if any, light; and lastly, that *corrosive sublimate* placed upon the same dish, exhibited one of the most beautiful phosphoric spectacles that can be seen. I believe nevertheless, that the dish was hotter in this last experiment than in those made upon luna-cornea and arsenic: and in general, I ought to give notice, that the intensity of the light was considerably affected by the heat of the supporting plate; and as it is not possible that this heat could have been precisely the same, in all these experiments, whoever shall repeat them, will probably

find

find some difference in the results, although I do not believe that these differences will be considerable, as I took all the care I could to keep this degree of heat nearly the same.

These facts are not yet sufficient in number to enable us to draw any general conclusion from them. It will be necessary, as I have already said, to multiply these proofs much more, and they certainly well deserve to be prosecuted.

Addition to the Article PLATINA.

SINCE our experiments on platina, the *Count de Buffon*, the *Count de Milly*, M. *de Morveau*, the *Baron de Sickingen*, and others have made new interesting researches on this singular metallic substance. Excepting those of the *Baron de Sickingen*, which are not yet published, the others are related at length in the first volume of the supplement to Mr. *Buffon*'s Natural History. This illustrious naturalist gives an account of the experiments which he himself made, and those which he made along with Mr. *Tillet*, of the Academy of Sciences, to determine the specific gravity of platina. These experiments consisted in comparing it with pure gold, by weighing an equal bulk of each of these matters in particles or grains, nearly of the same size and form, and the bulk of which was determined by the space which they occupied in a quill. Considerable differences were observed in weighing different parcels. But when the average of these trials was taken Mr. *Buffon* estimates, that the specific gravity of platina is less than that of gold by one twelfth part.

Having carefully examined the magnetism, both of the ferruginous sand naturally intermixed with platina, and of the grains of the platina itself, and having found that almost all these matters were more or less sensible to the action of the magnet, Mr. *de Buffon* concludes from these observations and from several experiments of of the Count de *Milly* and of M. de *Morveau*, which I shall presently mention, that this metallic matter is not a particular metal like gold, or silver, but is an allay made by nature, of gold and iron in a particular state, and combined together more intimately than can be done by art. I do only relate this opinion, which is also that of M. de *Milly*, without entering into an examination at this time of its probability, that we may not interrupt the recital of the new experiments that have been made on platina.

M. de *Milly* having digested in spirit of nitre some grains of platina which were no longer attracted by the magnet, and not having remarked any effervescence, or other sensible mark of solution, he then mixed this acid with some of the alkaline liquor that was saturated with the colouring matter of Prussian blue, and did nevertheless produce a blue; from thence M. de *Milly* concluded that this

platina

tina, although not capable of being attracted by a magnet, did vever contain some iron which the nitrous acid had taken from But M. *Morveau* repeated this experiment, and did not thereby duce any Prussian blue.

This excellent chemist pushed very far his trials upon the fusion cupellation of platina. He was able to melt it in a wind-furce, without any metallic addition, and by means of a reducing of his invention, composed of eight parts of pulverised glass, one part of calcined borax, and of half a part of powdered char-l. I have myself been a witness of the efficacy of this flux in ons of iron-ore, which were effected by Mr. *Morveau* in my nace and in my laboratory, along with the *Duke of Rochefoucault*, . de *Trudaine*, Mr. *Lavoisier*, and some other distinguished che-ts. We obtained a button of iron perfectly well fused, well re-ed, and on which was marked distinctly the crystallisation which . *Morveau* never fails obtaining in the essays of ores of iron, the cess for which he has considerably improved.

With regard to the cupellation of platina by means of lead, we d in Mr. *Buffon*'s work, which I have quoted, the detail of the e experiments which Mr. *Morveau* has made to push this opera-n as far as it can be carried in the furnaces of laboratories. He ployed for this purpose an air-furnace, of which I have given escription in the memoirs of the Academy of Sciences. After had cupelled a mixture consisting of one gros of platina and two s of lead, in four successive operations, during which this fur-ce had been carefully supplied with fuel so as to produce its eatest heat, which lasted in all eleven or twelve hours, he at gth obtained a button of platina, well collected, not adhering the cupel, of a continued uniform colour, more nearly resembling colour of tin than any other metal, only a little rough, weigh-g an exact gros, and not sensible to the action of the magnet.

I have since that time made some other experiments of the cu-llation of platina, in the the focus of the great burning glass of . de *Trudaine*. I will not give the detail of these experiments cause they are not yet finished, but shall only say, that having posed at five different times, a mixture of equal parts of lead and atina, to the focus of this powerful instrument, I obtained a mass newhat granulated, like matted silver, which did not smoke any ore in the focus, as white as the purest silver, and received no eration in its colour by exposure to air. I was not able to weigh is button, because it was fixed in a mass of glass which proceeded om the fusion of the substance on which it was placed. This atina, the whitest that I have ever seen, and which I have reason believe to be the purest, could easily be filed, and became po-ed under the hammer. I return to Mr. *Morveau*'s experiment.

Upon

Upon a further examination of the button which proceeded from this cupellation, its specific gravity was found to be that of water as fourteen and two-fifths to one, while that of pure gold, when compared to it was as nineteen and one thirty-fourth. It is remarkable that this button, which was not malleable, having been broken, the fracture shewed several cavities, some of which about a line in diameter, had the whiteness and brilliancy of silver; a circumstance which sufficiently shews that its specific gravity as above-mentioned was not just.

A part of this same button, which did not appear sensible to the action of the magnet, having been reduced in an agate-mortar into a very fine powder, these particles gave still some signs of magnetism.

"Lastly, Messrs. *Buffon* and *Morveau* observed together that by "bruising this cupelled platina, its parts resumed precisely the "same roundish flattened forms as they had before their fusion. "According to Mr. *Buffon*, this operation seems to prove that "although the fire was strong enough in the experiments of M. "de *Morveau*, not only to burn and vitrify, but also to expel a "part of the iron with the other vitrescible matters which it con-"tains, the fusion is nevertheless not so compleat as that of the "perfect metals, since, when it is bruised, the grains resume the "same figure which they had before fusion."

This remark appears so much the more just, as upon a thorough examination of the properties of the several parcels of platina which I had melted by different processes, none of them seemed to be possessed of such a malleability as was perfect, or proportionable and correspondent to its other metallic properties. This matter is in fact so refractory, that perhaps it never did enter into a compleat fusion, and that what has been considered as such, has been really nothing but a more or less intimate agglutination of its parts. This happens, I believe, in an apparent fusion of platina, which may be effected by a moderate heat, according to M. *de l'Isle*'s experiment, which I have verified, and which consists in exposing to a good ordinary fire of a furnace or forge, some platina precipitated by sal ammoniac from its solution in aqua regia. This precipitate seems to melt easily enough into a metallic mass smooth and dense, but it perfectly wants malleability while it is exposed to a moderate heat, and resumes an imperfect degree of it only in proportion as the heat is rendered more intense. The parts of platina being infinitely divided in the above-mentioned precipitate, it is not astonishing that heat should penetrate such small particles much more effectually than ordinary grains of platina, which are enormous masses in comparison, and as their softening is in proportion, they ought to suffer the ordinary effect of their agglutination, in proportion to their points of contact; but as these points are infinitely

more

re numerous than those of much larger molecules can be, the d masses which result from the fusion have the appearance of a tal that is dense, melted, and hardened by cooling, but in reality y are only the result of a simple agglutination between an infinite nber of particles infinitely small, and not that of a perfect fusion, the fusion of other metals. At least this account of the matter ns to me to be the most probable.

do not know if all the experiments hitherto made on platina sufficient to enable us to decide concerning the nature of this tallic matter. I have already said that I was inclined to con- er it as a particular metal, as simple and perfect in its kind, as other metals are in theirs. The only objection that has been de, or that may be made against this opinion, is, that platina, hough it possesses the essential properties of metals, and even of perfect metals, has not however either the fusibility, or all the ility of the simple metals.

As to the ductility, it depends on a good fusion, not only of this tal but also of the others; and it depends so visibly upon this se in this instance, that the ductility of platina is found to be in portion to the degrees of heat, and of the softening or aggluti- ion that are given to it. It is a truth of which I am convinced a great number of experiments, and I doubt not but the other emists who have worked upon this matter have made the same servation. The want of fusibility remains: but besides that this not an absolute and limited quantity; that it is only relative to different nature of each body; it is certain that, without going t of the class of metals to bring instances, the difference between fusibility of lead and the purest forged iron, is enormous; and s difference, however great it is, does not hinder, and ought not hinder iron from being considered as a simple metal with as good son as lead. Why then should not a gradation be admitted for metallic bodies? Why should platina, whose fusibility is not so different from that of iron, as the fusibility of iron differs from at of lead, be excluded by this sole difference from the rank of nple metals; and how shall we determine the limits of fusibility, rather of the difficulty of being fused, beyond which a metallic atter cannot be reputed any thing but an allay, and not a simple etal? Certainly we cannot give any good answer to these ques- ons, and it follows from thence that all which we know of the operties of platina do not prove that it is not a simple metal, like e others. Let us see then what may be the motives which have ade it considered as an allay of gold and iron. This mineral has, is said, properties which partake of those of gold, and of those iron. Its colour, density, hardness, and magnetism may be itated by allays of these two metals in certain proportions. Lastly, whatever degree of purity platina may be brought, it always

gives

gives some marks of magnetism, which prove that it is not entirely exempt from the allay of iron.

I acknowledge that as compounds partake most frequently, to a certain degree, of the properties of their component parts, and that in fact some properties are observed in platina which resemble those of gold and of iron, there are sufficient grounds for a suspicion that it may be only an allay of these two metals. But it must be also acknowledged that this can be nothing more than a mere suspicion, while there are no other proofs to support it than an imperfect resemblance, like that which we have mentioned. But it is certain that the proofs of those who embrace this opinion extend no farther; for to whatever trials platina has hitherto been subjected, the gold has not been separated by any of the methods by which this metal may be separated from its allay with other metals, particularly with iron; and also, in whatever manner and in whatever proportions gold has been combined with iron, no allay has been ever made which could be considered as an imperfect platina.

To this it is answered, that the iron which is thus combined with gold in the platina is not in its ordinary state; that this metal is found daily in very different forms and states; and lastly, that it requires to be in a very peculiar state to enable it to form with gold true platina.

In the first place, I shall observe upon this subject that this supposition is repugnant to all the positive and ascertained facts in metallurgy, all which concur in proving, that no metal can be allayed in its compleat metallic state with another metal, unless this latter also be in its compleat metallic state: And if it be said, that we ought not to confine our reasonings to the routine of chemists, and that nature finds the means of making combinations which they are not acquainted with; we may acknowledge that such an allay as is here mentioned is not shewn to be impossible in this sense, but nevertheless, in order to make me believe that it really does exist, it will be necessary to shew that platina has been made by combining gold with iron in that state which is supposed to be necessary for imitating the process of nature. For it is very evident, that if we were permitted to allege mere possibilities, to support which we have occasion for as many suppositions as there are difficulties that occur, we might prove whatever we pleased; for instance, that gold is nothing but an allay of silver and copper, which copper is in a certain state, and combined by means very different from those employed in ordinary chemical processes.

As to the small portions of iron which remain obstinately united to platina, notwithstanding the effects of the greatest heat, and of the strongest cupellation; this phenomenon is not peculiar to these metallic matters. It is even very general, since it is constantly observed in all the analyses of parting, and in the other operations of

chemistry. Whenever one substance is separated from another, last portions of that whose quantity is the smallest, are so much more difficult to separate as less of it remains, so that at last we d that a perfect separation cannot be obtained. This is the rea- why it is so difficult to attain a purification that is so rigorously fect: Thus, for instance, it is almost impossible to bring gold the mathematical degree of fineness of 24 karats. Although refore, the allay of iron were no more essential to platina, than t of silver or of copper is to gold, it would not be any matter of prize, if we could not separate perfectly the last infinitely mi- te portions of this metal, which are allayed with it in its native te. Nevertheless I can affirm that the platina of a shining white our like silver, which I have obtained by cupellation in the focus a large burning glass, did not shew any signs of magnetism by e most accurate trials that I was able to make. Not only this np of platina appeared to be quite insensible to the action of a ry strong artificial magnet, but also when I made it float freely on the water by means of a piece of cork, I could not observe at the magnet produced the least motion in it, not even when I uched it with a magnet that was capable of sustaining six ounces. endeavoured to repeat the experiment of Mr. *Morveau* upon this me platina, that is, to reduce it into very small parcels. For that irpose, I bruised a small piece of it between two flat surfaces of ck crystal, but I found that this little piece, which weighed about h of a grain, and which could only be flattened and polished by is means, was not attracted in any degree by the magnet, even hen it was made to float upon water by means of a bit of wax.

These experiments seem to me to shew, that if it is not possible separate the last atoms of iron allayed with platina; we may at ast carry this separation so far, that nothing remains of it but a uantity infinitely small and not to be estimated. But it is a re- nark worth making, with which I shall close, that if platina be in act an allay of gold and iron, it ought to resume the properties of gold in proportion as it should be deprived of its iron, whereas, on he contrary, it thereby becomes more white, and the properties by which it differs from gold, become more distinct.

SOAPS (ACID.) Alkalies are not the only saline substances that are capable of combining with oils, so as to form compounds capable of solution in water and in spirit of wine. Perhaps indeed, rigorously speaking, every saline matter has some action upon oils, and communicates some degree of a saponaceous quality propor- tionable to this action. Nevertheless, the salts which are not evi- dently caustic, have but an infinitely small degree of action upon oils, and it would be an infinite labour to subject to a compleat che- mical examination all the salino-oily combinations that can be made. But as acids have in general a very strong causticity, and

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particularly a decided action upon oils, it was important to make at least the principal compounds that could result from these two sorts of substances, and to investigate the most essential properties of these new compounds, which had been absolutely neglected by chemists till lately. The academy of Dijon, who generally make choice of their prizes with much judgment, proposed the discussion of this matter as a proper subject As this prize has been deferred five years successively, we cannot doubt but several chemists have during that time been making experiments on this subject. I know particularly one very good memoir on acid soaps that was sent by Mr. *Cornette*, but it arrived after the expiration of the limited time, and therefore could not enter into the competition for the prize. The author intends to publish it soon. About the same time Mr. *Achard*, of the academy of Berlin, published an extensive work upon *soaps whose saline basis is vitriolic acid*; and as this memoir is printed in Mr. *Buchoz*'s journal called *Nature considered under different Aspects*, I shall mention the principal experiments made by Mr. *Achard*, without pretending to decide concerning the debates about the analogous experiments and discoveries, which other chemists and particularly Mr. *Cornette*, have made on the same matters.

"The process, which succeeded with Mr. *Achard* in making acid "soaps by combining vitriolic acid with oils, both concrete and "fluid, drawn from vegetables by expression, or by boiling, con-"sists in putting two ounces of concentrated white vitriolic acid "in a glass mortar, and in adding to this by degrees, and during a "constant trituration, three ounces of the oil of which the soap is "intended to be made, which had been previously heated, even "almost to ebullition. Mr. *Achard* obtained by this process, black "masses which when cooled had the consistence of turpentine.

"According to the author's remark, these compounds are al-"ready true soaps: But in order to bring them to a more perfect "and more neutral combination, it is necessary to dissolve them in "about six ounces of distilled boiling water. This water takes up "the superabundant acid that may be (and which probably is "always) in the soap; and the saponaceous parts join together "when the water cools into a brown mass of the consistence of "wax, which sometimes occupies the bottom of the vessel, and "sometimes swims upon the surface of the fluid, according to the "weight of the oil employed. If the soap still should contain too "much acid, which may be easily known by the taste, it is neces-"sary to dissolve it once more in distilled boiling water, and to "repeat this operation till it has entirely lost its acid taste. In "this manner a soap is obtained whose component parts are *in a* "*reciprocal state of perfect saturation*.

"Mr. *Achard* remarks further, that concentrated vitriolic acid "acts very strongly upon oils, and gives notice, that t is necessary

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" to take care that the oil be not added too ſuddenly, and in too " great quantity, becauſe in this caſe the acid becomes too ſtrong, " decompoſes the oil, and changes it to a ſubſtance reſembling " charcoal. This decompoſition is manifeſted by the ſmell of vo- " latile ſulphureous acid which exhales.

" When theſe ſoaps are carefully made, (ſays Mr. *Achard*) they " become hard by age; but if they contain a ſuperabundant acid, " they become ſoft in the air, the moiſture of which they attract."

This chemiſt has compoſed vitriolic acid ſoaps with different oils, ſuch as thoſe of ſweet almonds and of olives, butter of cacao, wax, ſpermaceti, and the expreſſed oil of eggs. He has made ſoaps with eſſential oils; but as the vitriolic acid acts much more forcibly and quickly upon eſſential oils than upon the other mild oils, and as it is always neceſſary in theſe combinations to avoid the too quick action of the acid; the proceſs for the compoſition of acid vitriolic ſoaps with baſes of eſſential oil requires ſome particular attentions and management, which Mr. *Achard* points out in the following manner.

" In the following proceſs (ſays he) I ſucceeded in making " ſoaps with vitriolic acid and any eſſential oil. I poured three " ounces of white oil of vitriol in a glaſs-mortar placed in cold wa- " ter. To this I added ſlowly, drop by drop, four ounces of the " eſſential oil that was intended to enter into the compoſition of " the ſoap. I triturated continually this mixture, and when it " began to be hot, I added to it no more oil, before it was entirely " cold. I continued this method till all the oil was mixed with the " acid. That being done, I poured about a pound of water upon " a pound of this mixture, and I heated it ſlowly, till it acquired " a heat nearly equal to that of boiling water. I then removed " the mixture from the fire. By cooling, the ſaponaceous parts " united into a brown maſs, more or leſs ſolid, according to the " nature of the oil employed."

The author gives notice that too great a heat occaſions a decompoſition of the oil by the vitriolic acid, and converts it into a ſemireſinous kind of coal, which is eaſily known, as alſo in the mixtures of the ſame acid with the oils that are not volatile, by the ſmell of volatile ſulphureous acid, which never fails to be ſenſible when it acts ſo ſtrongly as to decompoſe the oil. To prevent this decompoſition the above deſcribed cautions to keep the mixture cold are intended; and it is even neceſſary that the water added to cleanſe the ſoap from any ſuperabundant acid, ſhould not be made ſo hot as to boil.

Mr. *Achard* has made ſoaps of this kind with the eſſential oils of turpentine, fennel, and other oils, which though not ſtrictly eſſential, are no leſs volatile, as the oil of amber, animal oil of Dippel, and oil of wax.

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We cannot doubt, as the author very well says, that all these combinations of vitriolic acid with different kinds of oils, are true saponaceous compounds, acid soaps well characterised, when the combination has been properly made: for he found from experiments, that each of these compounds were soluble either in water or in spirit of wine, and capable of being decomposed by fixed or volatile alkalies, by calcareous earths, and by several metallic matters, all which substances seize upon the acid of the soaps, form with it new compounds, and disengage the oil, in the same manner as acids separate the oil from alkaline soaps.

Beside these observations, which are common to all these soaps, Mr. *Achard* has made upon each of them a great many particular experiments, which exhibit many very curious and important phenomena, in this respect, that they extend our knowledge on the nature of the different kinds of oils. It would be too long to enter here into these details, which may be seen in the work itself. I shall content myself with relating the principal results, and shewing the most general consequences which I think may be drawn from them.

Not only alkaline, and several metallic matters decompose vitriolic acid soaps, but also most of the other acids, as the nitrous, the marine, the volatile sulphureous, and even vinegar, are capable of effecting this decomposition, which is a very remarkable phenomenon. Nevertheless the effect of the acid of vinegar is not the same upon all these soaps, for it is not able to decompose some of them. Tartar and salt of gooseberries decompose these soaps; but there is reason to believe, as Mr. *Achard* thinks, that it is by means of the fixed alkali which the saline matters contain, that they produce this effect.

Several neutral salts, with different bases, do also decompose these acid soaps; some of them by the greater affinity of the vitriolic acid with their bases; and most of them by means of a double affinity.

But a very remarkable circumstance is, that in whatever manner these soaps be decomposed, including even distillation without any intermediate substance, the oil which is separated is found to possess and to retain a stronger consistence than it had naturally. Most of the oils thus separated become concrete and as hard as wax, whereas the oil that is separated from alkaline soaps, as Mr. *Achard* remarks, is more fluid and attenuated than in its native state. This effect appears to me to shew that the decomposition of acid soaps is not complete, and that the oil having been once combined with vitriolic acid, retains always a portion which augments considerably its consistence. The case is quite different with alkaline soaps; the alkalies when they combine with oils, seem to deprive these of a part of the acid naturally united in their composition, and to which

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ir natural consistence is owing; and when we separate these oils m the alkali, it does not restore to them all their acid, and accdingly the oils thus separated, become more fluid than they were ore they were combined.

Another general observation upon the decomposition of acid soaps alkalies, and which is no less important, is, that when we employ s method of decomposition, we must observe to add no more ali than the quantity necessary for the saturation of the acid, bese the overplus does not fail to combine with the separated oil, l to form with it an alkaline soap, even much more easily than the direct and ordinary combinations. Accordingly Mr. *Achard* narks, that the decomposition of the vitriolic acid soap of the estial oil of turpentine, affords an easy and quick method of making *rkey's soap*, which is so long and difficult by the ordinary prosses. To make this soap, nothing more is required, than to add the solution of this acid soap, a greater quantity of alkali than is cessary to saturate the acid, and then to make the mixture boil. this method, says the author, *Starkey's soap* may be made in a minutes. The reason of this effect is, that the fixed alkali ds in this operation the essential oil of turpentine, at the instant its separation from the vitriolic acid, in a much more perfectly vided state than can be effected by any other means.

We might probably avail ourselves of this same method, for the mposition of acid soaps, which in general are more difficult to made than the alkaline soaps, not only because there is danger decomposing and altering the oil, but also from the nature of combination, and from the excess of acid that ought to be added order to make it well, at least according to the process of Mr. *hard:* for Mr. *Cornette* has assured me that he has been able to ke these soaps with much less acid.

I have tried to combine vitriolic acid with lintseed oil, by adding adually the acid to the oil, instead of adding at different times all quantities of the oil to the acid, as Mr. *Achard* does, and I ve observed that the combination is soon effected by this method. evertheless the oil was much blackened and acquired a pitchy contence, had a considerable excess of acid, which partly separated deliquescence. Nevertheless this saponaceous compound apared to me to be imperfect, particularly because it was much less luble in water than in spirit of wine; which property seems to be mmon to all acid soaps, and even to alkaline soaps, but in a less gree.

I succeeded in making a soap with oil of olives and vitriolic acid, hich appeared to me to be perfect, in the following manner: I ssolved ordinary alkaline soap in vitriolic acid, taking care so to oportion the quantity of each, that there should be an excess of id in the mixture. At first, I tried to effect this combination by

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means of vitriolic acid diluted with much water, in order to prevent the oil from being blackened and altered. But although there was evidently an excefs of acid, the oil of the foap feparated partly in the ftate of a very white and very limpid oil, very foluble in fpirit of wine, but infoluble in water; partly into a very concrete oily matter, of the confiftence of greafe, very foluble in fpirit of wine, but unfoluble in water, and confequently the dilute vitriolic acid had not been able to act with fufficient ftrength upon the oil of the foap to reduce it into a faponaceous compound.

The cafe was very different when I triturated fome alkaline foap, made of oil of olives, along with concentrated vitriolic acid. From this mixture a brown compound refulted, which contained a perfect foap. In order to purify the foap, I diffolved it in fpirit of wine, which feparated from it all the falt of Glauber and vitriolated tartar which were formed during the operation. I then added to it gradually and carefully, fome liquid fixed alkali, in order to faturate the excefs of acid; by which means more vitriolated tartar was precipitated. Laftly, I filtrated the liquor which then appeared tranfparent and yellow. When it was fhaken, permanent bubbles appeared exhibiting the fame irifes as the bubbles of ordinary alkaline foap. I evaporated the liquor with the heat of 35 or 40 degrees of *Reaumur*'s thermometer, and during the evaporation yellow tranfparent drops were formed upon its furface, which I took at firft for oil that feparated; but when cold, it became a concrete yellow fubftance of the confiftence of greafe or fuet, having the fat rancid tafte of ordinary foap; with fpirit of wine a very limpid folution, without any feparation taking place; and this latter folution being evaporated to drynefs by a mild heat, was thickened into a foap of the fame nature as before its folution by water.

From thefe facts it appears that by the procefs which I followed, a perfect acid foap may be eafily formed with vitriolic acid and oil of olives. There is reafon to believe, that the oil is lefs altered by this method, than by a direct combination with concentrated vitriolic acid, although in the decompofition of ordinary foap by this acid, a flight fmell of volatile fulphureous acid is perceived. This acid foap is exhibited under the form of a fluid oil, when the fpirituous acidulous liquor in which it is at firft diffolved is evaporated from it, becaufe it liquefies at a very gentle heat, and becaufe the acid watery fpirit of wine can only keep in folution a determinate quantity of it. When there is a certain quantity of it thus collected upon the furface of this liquor, it may be eafily feparated by allowing it to become folid by cooling, and to pour off the liquor on which it fwims. When it is again rediffolved in water, and the folution is evaporated by a gentle heat, it thickens into a white acid foap, which feems to be poffeffed of all the qualities that could be expected in fuch a compound.

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...y be able to compose all other kinds of ... or by that of Messrs. *Achard* and ...cess more simple, more easy, ...much more importance to be ...aceous compounds seem to be ...r remedy which may be very ef- ...proceeding from obstructions and con- ...e diseases of that kind, where ordinary ...certain degree, and during a certain time, ...effect. It appears to me very probable, that ...ch happen too frequently, an acid soap substitut- ...an alkaline soap which has ceased to act, might ...effectual, and that the alternate use of these two reme- ...perhaps produce better effects than could be expected ...ther of them singly. At least many chemical operations ..., that the successive application of two solvents of different and ...opposite natures produces solutions which could not be effect- ...r but imperfectly by either of them alone. I have published a ...singular effect of this kind in the Journal des Sçavans, for ...ember, 1776, on the solution of the stoney depositions of ...e; and a great many other proofs may be seen in a letter filled ...very interesting researches and experiments on the same subject ...h Mr. *Morveau* has done me the honour to address to me, and ...ch is printed in the same Journal for February, 1777. As the ...s, although they are powerful and active solvents, have never- ...ess no causticity which can render them formidable to the most ...ent physicians, they may be tried with great safety, which in ...cine is no small advantage.

...ut besides this use of acid soaps which may become of the ...est importance, it is almost certain that they may become very ...l in arts and manufactures. In many arts the utility of com- ...soap is ballanced by inconveniences which, perhaps, the acid ...may be without. Time and experience alone will shew what ...t to be expected from them; for notwithstanding these first la- ...s so well begun, this subject may be considered as being only ...pened.

Addition to the Article SUGAR.

...Lthough a very small quantity only of oil be obtained by ana- ...lysing sugar in a retort, we cannot doubt that this substance ...ins a great deal of oil. This is proved from the phenomena ...e spirituous fermentation of which sugar is the true matter, ...rom the nature of the products of this fermentation which are ...flammable, and from several of which, a very great quantity ...l may be obtained, as Mr. *Rouelle* has very well observed; but

but this acid is ſo combined with the peculiar acid of ſugar, that it cannot be ſeparated by the ordinary analyſis. It is the peculiar combination of this oil and of the earthy parts with the acid, which gives to the eſſential ſalt the ſweet and agreeable taſte, and the fermentable and nutritive qualities which it eminently poſſeſſes; and it is very probable, that by ſeparating from its acid a conſiderable portion of its oil and earth, it might be obtained under the form of a very ſtrong and powerful concrete acid. At leaſt, this ſeems to be the reſult of ſome intereſting reſearches and experiments which Mr. *Bergman* has publiſhed upon this matter.

This intelligent chemiſt, by applying to ſugar and to other ſaccharine matters, a large quantity of nitrous acid, obtained from thence a very white, pure, well cryſtallized concrete acid, whoſe acidity is of ſuperior force even to nitrous acid, at leaſt with regard to the affinities, to which Mr. *Bergman* gives the name of *elective attractions*.

Theſe reſearches are publiſhed in form of a theſis ſupported by Mr. *Arvidſon*, and printed at Upſal in 1776. The proceſs to obtain this concrete acid of ſugar, conſiſts in diſſolving one ounce of ſugar in three ounces of good nitrous acid, and in drawing off afterwards the greateſt part of this acid by diſtillation in a retort, with a moderate degree of heat, till the liquor acquires a duſky brown colour. Mr. *Bergman* pours again upon this liquor three ounces more of good nitrous acid, and repeats the diſtillation, or rather the abſtraction, till no more of the ſmoking coloured nitrous acid paſſes into the receiver. He obtains, when the reſiduum of the liquor is cooled, a ſalt conſiſting of priſmatic cryſtals, which when drained upon brown paper, weighs one gros and 55 grains.

The liquor which floats above the cryſtals, being treated in the ſame manner at different times, with freſh nitrous acid, the quantity of the acid being diminiſhed each time, ſtill yields ſimilar cryſtalls, which being purified by ſolution, filtration, cryſtallization, and draining, form a total product of acid of ſugar in the proportion of three parts to thirty parts of the ſtrong nitrous acid employed in the operation.

This proceſs of Mr. *Bergman* ſucceeds very well, and has been verified by Mr. *Sage*. This concrete acid of ſugar has the appearance, the acidity, and ſeveral of the properties of ſalt of gooſeberries. Mr. *Bergman* has examined all the combinations that it forms with ſaline, alkaline, earthy, and metallic ſubſtances, and has very fully related the reſults in the diſſertation above quoted, to which I refer. I ſhall only ſay, that we find from Mr. *Bergman's* experiments, that this acid is in general very ſtrong and very fixed, and that it combines ſo intimately with earthy and metallic ſubſtances, that moſt of the ſalts which it forms with theſe baſes are inſoluble, or very little ſoluble in water; that it ſeparates the

ſtrongeſt

ſtrongeſt acids from almoſt all metals; and, what is more extraordinary, is, that it decompoſes gypſum and ſelenites even without heat. If ſome of this acid be put into water ſaturated with gypſum or ſelenites, it occaſions a precipitation, which is nothing elſe than an inſoluble ſalt reſulting from its combination with the earth of gypſum and ſelenites, from which it conſequently ſeparates the vitriolic acid.

Mr. *Bergman* makes a very happy and important application of this powerful affinity of the acid of ſugar with calcareous earth, to the theory of the fabrication of ſugar. This excellent chemiſt has aſcertained by experiments, that the acid of ſugar, and even the other vegetable acids added to a ſolution of ſugar prevent abſolutely its cryſtallization. Thence he concludes, that the difficulties which occur in boiling and cryſtallizing the juice of ſugar-canes, proceed principally from the ſuper-abundance of acid that is in ſugar, as well as in other ſaccharine juices; and conſequently, that the beſt addition which can be made to it to effect this cryſtallization is that of quick-lime, the utility and neceſſity of which are evinced by experience. The reaſon of it is, that this earth, at the ſame time that it abſorbs powerfully the ſuper-abundant acid of the ſugar, forms with it an inſoluble ſalt, which either precipitates or riſes with the ſcum. The ſaline alkalies do indeed abſorb, in the ſame manner as quick-lime does, the ſuper-abundant acid, but they form with it ſalts which remain diſſolved in the liquor, and do not ſeparate like the ſalt with baſis of calcareous earth.

Mr. *Bergman* is a chemiſt too intelligent not to perceive an objection which may be made to his account of the acid of ſugar. It may be ſuppoſed that this acid is not the proper acid of ſugar which pre-exiſted in this mixt before the application of the nitrous acid, but a new combination, reſulting from the union of this latter acid with ſome of the conſtituent parts of ſugar. The anſwers of Mr. *Bergman* are taken from the compariſon which he makes of the properties of his new acid with thoſe of the nitrous acid: he ſhews, that excepting the general properties of all acids, the acids of ſugar and of nitre, not only do not poſſeſs any peculiar properties that are common to them both, but alſo thoſe properties which diſtinguiſh each of them, are very different and oppoſite to each other.

One of the moſt important objects of Mr. *Bergman*'s reſearches is, that they prove that ſugar properly ſo called is not the only ſubſtance whence this acid may be obtained from all the ſaccharine juices, flours, gums, and probably from all ſubſtances that are nutritive and ſuſceptible of the ſpirituous fermentation.

The uſes of ſugar and all ſaccharine ſubſtances are very extenſive and important. Theſe ſubſtances may be conſidered as the baſis and primary matter of all alimentary bodies, and of all kinds of wines and vinous liquors; and to cryſtallized and purified ſugar, every

every body knows the infinite advantage that we receive from it, by the improvement it gives to the taste of almost all our aliments, and by its preserving property, without which we should want many of the most agreeable and essential of the culinary and pharmaceuti preparation.

FINIS.

A
TREATISE
ON THE
VARIOUS KINDS
OF
PERMANENTLY ELASTIC
FLUIDS,
OR
GASES.

The SECOND EDITION, *revised*.

LONDON,
Printed for T. CADELL, and P. ELMSLEY, in the Strand.
M,DCC,LXXIX.

To

The Rev^d JOSEPH PRIESTLEY, LL.D. F.R.S.

The following *Treatiſe* on permanently elaſtic Fluids

Is Inſcribed

By the *Author*;

As a ſmall Tribute juſtly due to the *Philoſopher*,

Who, by the *Zeal*, *Sagacity*, and *Succeſs*,

With which he conducted his *Experiments* on theſe Fluids,

Has opened

Many New and Rich Sources of Knowledge

in

Natural Philoſophy.

PREFACE.

THE following ſheets are intended as an *Appendix* to the ſecond Engliſh Edition of M. *Macquer's Dictionary of Chemiſtry*, inſtead of the article *Fixable Air*, which was added to the former edition. This ſubject has been lately ſo ſucceſsfully cultivated, ſince the writing of that article, that a reviſal and large additions were neceſſary : but theſe not having been finiſhed in time for inſertion into their proper alphabetical place, when the ſecond edition of the Dictionary was printing, and being beſides too large for an additional article, the following Treatiſe is ſubjoined as an Appendix to that work.

The name of the ſubject is changed from thoſe commonly employed by Engliſh authors, viz. *Fixable*, *Fixed*, or *Factitious Air*, to that of *Gas*; a word applied to diſtinguiſh permanently elaſtic fluids by *Van Helmont*, who firſt diſcovered, or, at leaſt, deſcribed more clearly

than his predeceſſors, many kinds of theſe fluids. The impropriety of applying the word *Air* to all permanently elaſtic fluids is evident, from conſidering that this word has been immemorially appropriated to expreſs only one of theſe, namely, the atmoſpherical fluid, and that the other elaſtic fluids are very different in moſt of their properties, although they have been frequently confounded with it. The impropriety would not be greater, if all *liquids* were confounded under the name of *Water*. And probably the firſt diſcoverer of other liquids committed this impropriety. Oil he might call inflammable water; and vinegar, acid water.

The application of the word *Air* in a *generical* ſenſe to expreſs all permanently elaſtic fluids, inſtead of confining it to its ancient ſpecific meaning, denoting the atmoſpherical fluid, was introduced by *Boyle*, in conſequence of an erroneous opinion which he entertained, that all theſe fluids are modifications of the atmoſpherical fluid. This phraſeology, founded on error, has nevertheleſs been continued by the reſpectable philoſophers who have ſucceeded that author; although they were ſufficiently ſenſible of the difference between the atmoſpherical and the other permanently elaſtic fluids. Intent only on the communication of

of their own very important discoveries, they continued the language of *Boyle*, and extended it to the new fluids which occurred to them in their researches. Thus Dr. *Priestley*, in his late most successful prosecution of this subject, having observed not only many new properties of the fluids formerly known, but also discovered several new fluids, and finding that the word *Air* had been applied by his English predecessors to denote generally all permanently elastic fluids, has, in conformity with a language which appeared to be in some measure established, given to his newly-discovered fluids, the appellations of *vitriolic acid air*, *marine acid air*, *fluor acid air*, *nitrous air*, &c. And in continuing the same mode of appellation, he certainly consulted the ease of his readers, who were supposed to be conversant with the writings of his predecessors, and to whom he meant chiefly to communicate the further progress he had made in this subject.

But the circumstances under which the following Treatise is written, are so different from those of the celebrated authors who have so happily cultivated this subject, that the same reasons which may be alledged to shew the propriety of their continuance of the language of *Boyle* are not here applicable: for this subject has received so very rapid an

advancement within theſe few years, that it has riſen from a few ſcattered facts, to be now one of the moſt important branches of Natural Philoſophy; and this change is ſo recent, that no attempt has before been made to arrange theſe facts, and to give them the form and method of a ſcience. As I have firſt undertaken that taſk, it appeared not uſeleſs to reviſe the expreſſions hitherto employed; and as a *ſyſtematic* treatiſe, like the following, is chiefly intended for perſons beginning to ſtudy the ſubject, I thought that it ought to adopt that phraſeology which appeared to be the moſt perſpicuous, and leaſt capable of miſleading the judgment. But certainly the language which is entitled to this deſcription, is that in which known and eſtabliſhed words are applied and confined to their known and eſtabliſhed meanings, and new words are appropriated to expreſs new ideas. Now the word *Air* having been immemorially aſſigned to denote the fluid which we breathe, which is one ſpecies only of permanently elaſtic fluids, cannot be applied in a generic ſenſe to the other ſpecies of theſe fluids, without giving the idea of *Boyle*, that they are all modifications of that reſpirable fluid. And accordingly I have always perceived that perſons not converſant in the ſubject received this impreſſion from the names *Fixed Air*, *Factitious Air*, &c.

If

f it be alledged, that as *Boyle*, *Hales*, and the Engliſh philoſophers who have written the ſubject, have uſed the word *Air* in a eric ſenſe, they have thereby eſtabliſhed cuſtom. I grant that *cuſtom* is the arbiter language; but as in law, ſo in language, oms may be good or bad, according to ir extent. Now the cuſtom by which *air* been uſed in a generic ſenſe, is confined efly to a few Engliſh philoſophers: but cuſtom on which the ſpecific meaning of t word reſts, is popular, and ſo fixed in guage, that the combined authority of all philoſophers in the world could not induce nkind (when they mean to expreſs the well-own fluid which they breathe) to uſe the thets *common*, *reſpirable*, or *atmoſpherical*, which that fluid muſt be diſtinguiſhed by thoſe who employ the word *Air* in a gene- ſenſe. While therefore that word is ſo ployed, the philoſophical language will be variance with the popular language, and acquiſition of ſcience be thereby ob-ucted.

When *Van Helmont* obſerved that there were any fluids, beſides air, which were poſſeſſed a permanent elaſticity, and that the pro-rties of theſe fluids were different from thoſe air, he very properly gave one name to the whole

whole genus of ſuch fluids, and diſtinguiſhed the ſeveral ſpecies by deſcriptive epithets added to the common generical name. And as he ſeems to have been the firſt who had the idea of a genus of permanently elaſtic fluids, (his predeceſſors conſidering all but air as condenſable vapours) he accordingly applied a new word to ſignify this new idea. And in this conduct, he followed the example of all thoſe who have arranged natural ſubſtances into genera and ſpecies. The word which he applied to denote the genus of permanently elaſtic fluids, is *Gas*, and the epithets which he added to this word to diſtinguiſh the different ſpecies, are, *ſylveſtre*, *flammeum*, *ventoſum*, &c. According to *Junker*, (Conſpectus Chemiæ, Tabul. XIV.) *Van Helmont* derived the word Gas from the German *Gaſcht*, or *Gaſt*, which ſignifies a frothy ebullition or eruption of wind, ſuch as accompanies the expulſion of gas from fermenting or effervefcing ſubſtances. In this reſpect the etymology is not exceptionable; but perhaps the principal advantage of the word is, that its etymology is ſo far from being obvious, that it cannot lead to any erroneous opinions.

In this application of the word *Gas*, *Van Helmont* has been followed by many of the foreign chemiſts, and among others, by M.

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Macquer, the author of the Dictionary of Chemistry. But as this Treatise is intended principally as an Appendix to the English translation of that work, the same language ought to prevail in both, and this consideration too was an additional reason to induce me to adopt the present phraseology.

It has indeed been lately suggested that *Van Helmont* did not distinguish permanently elastic fluids from condensable vapours and exhalations. But I think a very different opinion will be formed on examining his works, in which the following observations, among many others on this subject, are found.

1. Certain fluids (to which he first gave the name of *Gas*) escape from various substances and in various processes. Among the many Gases mentioned by *Van Helmont* are, the *gas ventosum*, or air; the *gas pingue*, or the fluid extricated by applying heat to inflammable substances; the *gas sylvestre*, or the fluid produced by fermenting or effervescing substances; the *gas flammeum*, or the gas produced in the deflagration of *nitre*; the *gas* produced in the distillation of *tartar*; the *gas* produced in the burning of *charcoal*; the *gas* of the *Grotta del Cane*, of *mines*, and other *subterranean places*; the *gas* produced by the *putrefaction* of animal bodies;

bodies; the matter which occasions the *plague*; the *arterial ſpirit of life*; and laſtly, his celebrated *Archæus*.

2. Theſe Gaſes *differ from vapour*, which conſiſts of minute particles of water or other liquids, and which may be again reduced to the ſame bodies whence it was exhaled; whereas gaſes are incondenſable [*quod in corpus non cogi poteſt viſibile*; and *incoagulabile.*] *De flatibus* §. 33. *Paradox. ſecund.* §. 9. *Aura vitalis* *. Thus he obſerves, that the vapour raiſed from ſpirit of nitre by diſtillation, is nothing but that ſpirit rarefied, which paſſes wholly into the receiver, without any gas: but that upon adding any metal ſoluble in that acid, a gas is formed, which is capable of burſting the ſtrongeſt veſſels. *De flatibus* §. 67. This gas is evidently that which is now ſo well known by the name of *Nitrous Air*, and which we have deſcribed in chap. X. under the name of *Nitrous Gas*.

3. The Gaſes *differ alſo from atmoſpherical air*, (which however he calls ſometimes *gas ventoſum)*

* He ſays indeed that the vapour of water when raiſed into the upper regions of the air may, by cold, be converted into gas; and that gas may, in length of time, loſe its peculiar nature of gas and be converted into water. But this opinion is only a conſequence of his general theory, that water and air are the two elements from which all things are formed. *Gas aquæ* §. 13. *Complex. atq. Miſtion. elem. figm.* §. 58.

ſum) and are not to be conſidered as air which had been pent up in the interſtices of bodies. *Complexion. atq. Miſtion. elem. ſigm.* §. 19.

4. Gaſes do not exiſt, as ſuch, in the bodies, whence they are expelled, but are *new productions* formed, by the action of fermentation, fire, and other cauſes, from the deſtruction of bodies, and by means of new combinations. Thus he obſerves, that the gas formed in the deflagration of gun-powder, did not exiſt in the nitre, ſulphur, and charcoal, but is formed by their action on each other, and mutual deſtruction. *De flatib.* §. 62, 63. 67, 68. *Complexion. atq. Miſtion. elem. ſigm.* §. 21, &c.

It muſt however be confeſſed, that *Van Helmont*'s knowledge of theſe fluids does not ſeem to have had much foundation in experiment, or any other ſupport than the caſual obſervation of an ingenious man, more intent on framing theories than eſtabliſhing new facts. For when his doctrines became exploded, the facts he mentions were ſo neglected, that notwithſtanding the exiſtence of ſo many gaſes is aſſerted by him, I do not believe that his writings ſuggeſted the idea of any one of them to thoſe who afterwards diſcovered them: and it is now only, ſince their exiſtence has been again diſcovered and aſcertained, that we trace them

them in the works of this author, as a matter of curiosity. While therefore we applaud the sagacity of *Van Helmont*, in having observed the existence of many permanently elastic fluids, and in distinguishing them from condensable vapours, and also from air; we ought not in justice to make any abatement from the honour due to *Boyle* and his successors who afterwards discovered the existence and properties of these fluids, collected them in separate vessels, subjected them to various modes of experiment, and thence made applications to explain the phenomena of nature. I have therefore omitted making any further mention of *Van Helmont* in the following chapters, having here collected into one view the sum of what I think is due to him.

I believe the following Treatise is the first attempt to arrange the knowledge which we have acquired on this subject, the gentlemen to whom we are obliged for this knowledge, having only communicated their proper discoveries. Neither should I, at this time, when this branch of Experimental Philosophy is generally cultivated in many parts of *Europe*, and every day brings forth new truths, have thought of the present task, if it had not been a necessary supplement to the edition of the Dictionary of Chemistry now published. M. *Lavoisier* has indeed

indeed given an account of the progreſs made by the ſeveral philoſophers who have advanced our knowledge on the ſame ſubject. But his plan is very different from mine. He relates the diſcoveries in the order in which they occurred to their authors; thus including in one chapter all the diſcoveries made by one man concerning many different kinds of fluids. I relate theſe diſcoveries in the order in which they are naturally connected; thus collecting into one chapter all that is known concerning one fluid; and at the ſame time aſſigning each diſcovery, concerning this fluid, to its proper author. M. *Lavoiſier*'s work is uſeful and entertaining, eſpecially to thoſe who are already converſant on the ſubject, as it ſhews how much each perſon has contributed. Mine I hope will not be leſs uſeful, as it preſents the ſcience in the order in which it is naturally connected, and in which it may be moſt eaſily attained. But while I expreſs my hope that this Treatiſe may facilitate the ſtudy of the ſubject to learners, and may even be agreeable to perſons already informed, by exhibiting under one view the principal diſcoveries and obſervations arranged under their proper heads, yet my aim is not to *ſatisfy* the curioſity of readers, but rather to *excite* it, ſo that they may recur to the ſame valuable originals, of which I have rather extracted the heads, than exhauſt-

exhaufted the contents; and where they will find many obfervations tending to confirm the principal refults; many facts curious, but too detached for infertion in the following pages; and much ingenious fpeculation.

ERRATA.

Page 21. *Note*. Line 12. Inftead of—" a green matter which " adheres to the fides of veffels filled with water, does, in a few " hours after it is put under an inverted jar full of water, emit " a confiderable quantity of *pure* air," read—" the water which " has depofited a green matter, that ufually adheres to the fides " of veffels filled with water, being put into an inverted jar, " emits a confiderable quantity of pure air."

Explana-

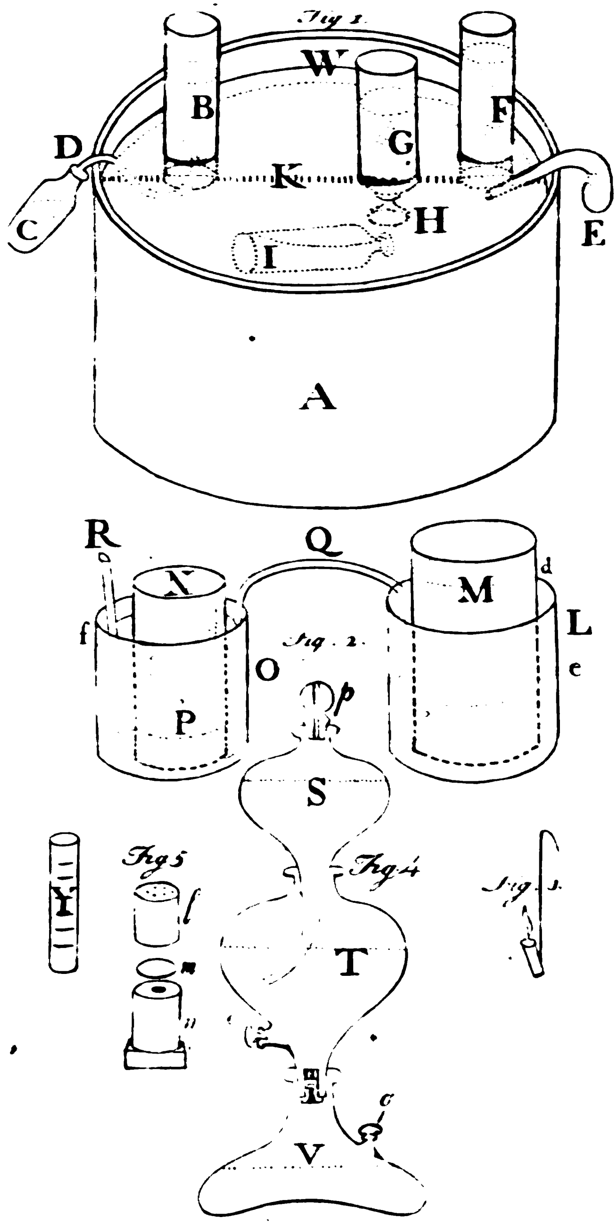
Fig 1.
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Fig. 2.
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Fig 5
Fig 4
Fig 3.
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Explanation of the PLATE.

TO ſhew the method of making experiments on the elaſtic fluids or gaſes deſcribed in this Treatiſe, the annexed plate and the following explanation are added.

The gaſes ought to be contained in jars, or other glaſs veſſels, B, G, F, (*Fig.* 1.) whoſe mouths are inverted into water or ſome other viſible fluid, that the gaſes may be kept ſeparate from the atmoſpherical air, and that their bulk may be diſtinguiſhed.

When a jar, as B, is intended to receive any gas, it ought to be previouſly filled with water, and its mouth inverted into another larger veſſel, containing alſo water, ſuch as the oval or oblong wooden tub A, which ought to be raiſed ſo that it may be as high as the operator's hands. This tub, being filled with water up to W, is a very convenient veſſel for receiving ſuch inverted jars; as it affords room for ſeveral of them to ſtand in it at once; and thus the gaſes contained in them may be poured from one jar into another jar, or other inverted bottle G. If the mouth of the bottle G be narrow, the transfuſion of gas into it from another veſſel I, is facilitated by the funnel H. This method of pouring gaſes from one veſſel into another, by immerſing the mouths of the veſſels under water, is deſcribed by the Hon. Mr. *Cavendiſh*, Phil. Tranſ. 1766.

In the tub A, Dr. *Prieſtley* places a ſhelf K a little below the ſurface of the water, for the more commodious ſupport of jars containing the different kinds of gas. The jar B, which is to receive the gas, ought to be placed ſo upon the ſhelf, that one of the edges of its mouth ſhall hang over the ſhelf, and that the mouth of the glaſs tube D may be allowed to paſs under that edge; by which diſpoſition the gas iſſuing from the phial C through the tube D may riſe

into the jar B. Some perſons recommend to have the ſhelf pierced with a row of holes along its edge, and to have a ſmall funnel with its mouth inverted fixed into each of theſe holes.

In order to procure gas, let the materials, which are to yield it, be put into a phial C, into the neck of which is ground a bent glaſs tube D: or, the tube may be made to paſs through a cork fitted into the mouth of the phial, in thoſe operations where the materials employed are not capable of corroding the cork, and thereby of altering the quality of the gas. Let the end of the bent tube which is moſt remote from the phial, be ſunk in the water of the tub A, ſo that it ſhall be immediately under the mouth of an inverted jar B previouſly filled with water, and that the gas produced from the materials in the phial ſhall paſs through the tube into the jar, in which it will diſplace part of the water, and be collected. If heat be required for the production of the gas, the flame of a candle or of a lamp may be applied to the bottom of the phial, which ought to be blown thin and round, that it may be leſs liable to crack by the heat. The above method of procuring gas is employed and deſcribed by Dr. *Prieſtley*, in his *Obſervations and Experiments upon Air*.

This operation may alſo be very well performed, by employing, inſtead of the phial and tube, a ſmall retort E, with a long narrow neck, the mouth of which is immerſed in water under the mouth of an inverted jar F. Such ſmall retorts are very convenient, as they have no joints; and where conſiderable heat is to be applied, a chafing-diſh with lighted charcoal may be put under their bottoms.

When a heat greater than glaſs veſſels can ſuſtain is to be applied, the materials are to be put into a gun-barrel, or other metallic tube, and the cloſe end of the barrel, in which the materials lie, may be put between the bars of a common grate, among the burning coals, and to the mouth of the barrel may be fitted, by means of lute, a glaſs tube, the

noſe

nose of which may be placed under the mouth of an inverted jar previously filled with water, and standing in the tub, into which jar the gas expelled by the violent heat from the materials in the gun-barrel will pass and be collected.

As some gases are capable of being absorbed by water, such as the *acid* and *alkaline* gases, this liquid is not fit to be employed to contain them, &c. therefore quicksilver must be substituted. For this purpose Dr. *Priestley* recommends the use of a small wooden trough to contain the quicksilver, in which the same operations with smaller jars may be performed, as are above described to be done in the wooden tub, *Fig.* 1.

When a jar containing gas is to be removed from the tub, let a hollow plate, saucer, or other vessel, whose orifice is wider than that of the jar, be immersed in the tub, and slipped under the inverted mouth of the jar. The two vessels may then be removed from the tub, and the external air will be prevented by the water contained in the lower vessel from entering the jar and mixing with the contained gas. By this method any number of jars containing gas of different kinds may be set apart, for future experiments, and when there is occasion to pour any of the gas contained in them into other vessels, they must be again immersed in the tub, and the transfusion performed as before directed. When, in making experiments upon these fluids, jars containing gases of different kinds are set apart, it is necessary to ticket them, in order to prevent mistakes.

When a quantity of gas is to be transported to a distant place, a bottle may be filled with it by means of a funnel in the manner represented in *Fig.* 1. G, H; and a cork may be introduced under water into the neck of the bottle. The gas thus contained in the bottle, and secluded from the external air by means of the cork and the small quantity of water that remains in the neck of the bottle, with which the cork is kept moist, may be carried safely to any distance,

 if

if care be taken to keep it in an inverted position.

That the gas may be mixed with as little air, as is possible, it is proper to allow the effervescence of the materials to proceed during a minute or two before the mouth of the tube or of the retort be put under the inverted jar. By this method the greatest part of the air contained in the vessels is thrown out; although some small portion will always remain. If the gas should be required perfectly free from air, the following apparatus may be employed.

Into two glass jars L and O (*Fig.* 2.) let two smaller jars M and N be inverted; and let a communication be formed between the two inverted jars, by means of a bent tube Q, each extremity of which opens into one of these jars. Under the inverted jar N, let a smaller vessel P be placed to contain the effervescing materials. The air contained in the several jars and tube is to be expelled, by plunging them into the water of the tub A, and joining them while immersed and full of water, in the order represented in the plate. The apparatus thus joined, and full of water, may be removed from the tub, and set upon a table. To prevent the water contained in the jars from running over during the effervescence, part of it ought to be drawn off from the jars L and O, by putting the shorter leg of a syphon or bent tube, previously filled with water, into either of these vessels, till the surface of the water in the outer jars be lowered to about the height of the dotted line *e*. The apparatus being thus prepared, if the matter, from which the gas is to be procured, be a liquid, as the solution of potash in water, it may be poured through the tube R into the vessel P; and an acid may be afterwards poured through another similar tube into the same vessel, where the acid and alkaline liquors mixing with the water contained in the vessel, and with each other, produce an effervescence. The gas rises towards the top of the inverted jar N, and pushes the water into the

the jar O. As more gas rises, it occupies more and more of the ſpace of the jar N, and it gradually forces its way through the bent tube Q into the jar M, where it is collected. For, its paſſage through the tube Q into the jar M, is reſiſted only by the column of water contained in the jar L, that is, from the ſurface of the water at *e*, to the bottom of the jar L; whereas the eſcape of the gas under the inverted mouth of the jar N, is reſiſted by the column of water in the jar O, the height of which is meaſured by the diſtance between *f*, repreſenting the ſurface of the water, and the bottom of the jar. And this column is rendered higher than the former column; becauſe a part of the water of the jar N is forced out of it into the jar O, by the gas occupying the upper part of N. But when the gas paſſes into the jar M, it forces part of the contained water into the jar L, and may raiſe the column of water there ſo high, that the gas ſhall eſcape under the inverted mouth of the jar N into the open air, more eaſily, than it can paſs through the tube Q into the jar M. It is therefore neceſſary, during the operation, ſometimes to draw off part of the water from the jar L, by means of a ſyphon, that the paſſage of the gas into the jar M may be facilitated. When the jar M is nearly full of gas, it may be raiſed a little, in order to diſengage it from the end of the tube Q, and may be then removed along with the jar L; and two other ſimilar jars, one inverted within the other, and both previouſly filled with water, may be ſubſtituted in the place of L and M, to receive the gas which continues to paſs through the tube Q. The operation may be continued by changing the jars, and by adding occaſionally more alkaline or acid liquor through the tube R; and large quantities of gas obtained without any mixture of external air.

If the ſubſtance, from which the gas is to be produced, be ſolid, as marble, or metals, it may be put into the veſſels P, before the apparatus is removed from the tub of water, and the acid liquor may be poured

poured upon it through the tube R, as above described.

If considerable heat be required to produce gas perfectly free from mixture of external air, the most accurate method of accomplishing this purpose is that practised by Dr. *Priestley* in some of his experiments, namely, to put the substance, whence the gas is to be produced, into a phial, the bottom of which is thin and round; to fill up the phial with mercury; to invert this phial into a bason containing mercury; and to throw the focus of a concave mirror, or of a lens, upon the substance, which being lighter than the mercury, will float on the surface of this fluid, under the thin bottom of the inverted phial.

To try the effect of any gas upon the flame of a candle, let a piece of wax taper be fastened to one end of a wire, as is represented in *Fig*. 3. and let the lighted taper be dipt into a small jar Y, previously filled with the gas or air to be tried.

When the diminution occasioned by mixing nitrous gas with air is to be observed, it will be proper to have two or more small jars Y, graduated with a file or diamond, each degree being equal in contents to an ounce measure of water, or to any other given bulk. By means of these graduated jars, the quantities intended to be mixed of the air and nitrous gas may be first measured separately, and the diminution, which they suffer by their action on each other, may be collected from observing the space occupied by them, after they have been mixed.

Signor *Landriani*, Abbe *Fontana*, and Mr. *Magellan*, have each invented instruments, which they call *eudiometers*, by which the diminution upon mixing air with nitrous gas, and consequently the degree of salubrity of the air examined, are intended to be ascertained more commodiously, especially upon journeys, than by the abovementioned apparatus of graduated jars. But notwithstanding the ingenuity shewn in the contrivance of these instruments, the greater simplicity of the graduated jars will, perhaps, claim the prefe-

preference. For although this apparatus requires a pretty large veſſel of water, in which the transfuſion of the air and gas is to be performed, and although it is therefore not ſo portable as the *eudiometers*, yet no inconveniency will ariſe, when we conſider the facility of tranſporting the air to be tried. For which purpoſe, nothing more is required than to carry a phial filled with water to the place, the air of which is to be examined, and to empty the phial in this place; by which means it will become filled with the air required, and by corking the phial, the air will be prevented from mixing with any other air, and may be kept till a convenient opportunity offers for trying its purity, by mixing it with nitrous gas in a graduated jar, as is above deſcribed.

Fig. 4. repreſents a ſection of an apparatus of glaſs veſſels, in which water may be impregnated with the gas extricated from chalk and other calcareous or alkaline ſubſtances, by means of acids. *See chap. XIV. of this Treatiſe*, §. 118. This apparatus, which was invented by Dr. *Nooth*, and is deſcribed in the *Phil. Tranſ. vol. 65th*, conſiſts of three veſſels, S, T, and V, well fitted, by grinding, into each other, in the manner repreſented in the plate; and of a glaſs valve placed in the lower neck of the veſſel T, ſo contrived, that it ſhall admit the gas, which is extricated from the effervescing materials contained in the veſſel V, to paſs from this veſſel into the veſſel T containing the water to be impregnated; but that it ſhall prevent this water from falling into the veſſel V. This valve conſiſts of three pieces, views of which are repreſented upon a larger ſcale by the figures *l*, *m* and *n*. The pieces *l* and *n* are cylinders fitted by grinding into the lower neck of the veſſel T. The lower piece *n* is perforated along the axis of the cylinder. In the upper piece *l*, there are ſeveral very ſmall perforations parallel to its axis. Between theſe two perforated cylinders is placed the piece *m*, which is a ſegment of a ſphere, and is moveable. The level ſurface of this ſegment reſts upon the upper, ſmooth, and level ſurface

face of the piece *n*, covering the perforation, and thereby preventing the water contained in the vessel T from falling into the vessel V.

When the apparatus is to be used, let the upper vessel S be disengaged, and the vessel T be filled with the water to be impregnated. Let as much water be poured into the lower vessel V as is sufficient to cover the bottom of the vessel. Some powdered chalk is to be thrown into this vessel; and then, as much acid of vitriol, as may be thought sufficient to saturate the chalk, is to be added. These effervescing materials may be put into the vessel V, either through the mouth of this vessel, after the vessel T has been disengaged from it; or, without disengaging the vessel T, through the aperture *q*, which is afterwards to be accurately closed with a ground stopper. Lastly, the vessel S is to be fitted to the vessel T. When the gas rises from the effervescing materials contained in the vessel V, it passes through the perforation of the cylinder *n*; presses upon the level surface of the lenticular piece *m*; raises this piece a little upwards; escapes into the small space between the two cylinders *l* and *n*; and thence ascends through the small perforations of the cylinder *l*, and also through the water contained in the vessel T, in the upper part of which it remains collected. When the gas enters the vessel T, it forces some of the water, contained in this vessel, to rise into the upper vessel S, which is left open, or is only closed with a perforated stopper, that vent may be given to the contained air, when the water is thus forced into this upper vessel.

The gas remaining in the upper part of the vessel T is gradually absorbed by the water contained in this vessel; and this absorption may be promoted by frequent agitation, which brings new portions of the water into contact with the gas. The absorption of gas is also promoted by the pressure occasioned by the column of water raised up into the vessel S. For pressure facilitates the absorption, as Mr. *Cavendish* has observed. The pressure might be increased to any

given

given degree, by a valve (similar to the safety-valve of a fire-engine) fitted into the mouth of the vessel S; or by a mercurial gage, as has been proposed by Mr. *Warltire*, (*Exper. and Observ. vol. III. Append.*) And thus a much stronger impregnation of water with gas may be effected, than is possible without artificial compression. Cold also facilitates the absorption, as appears from the experiments of Dr. *Hales*. For the more commodious agitation of the water, Mr. *Magellan* has added to the above described apparatus two more vessels similar to S and T, by means of which the impregnation of water may be carried on at once in two sets of vessels, one of which sets is to be agitated, while the other is receiving the gas from the effervescing mixture in the lower vessel V, and thus the water in each set of vessels is alternately supplied with gas and agitated. By this method water may be impregnated with gas in a few minutes.

As the vessel V contains much air, at the beginning of the operation, it is proper to let the effervescence proceed, during some minutes, before the several vessels of the apparatus are joined together, that the greatest part of the air may be expelled, before any gas is collected in the vessel T. When the water is sufficiently impregnated, it may be occasionally drawn off at the spout *o*, by removing the stopper.

To the water thus impregnated with gas ingredients may be added to give to it the peculiar qualities of the several mineral waters. Thus by adding a piece of iron to the impregnated water, the chalybeate property of *Pyrmont* water may be communicated.

Dr. *Priestley* impregnated water, by exposing it to the stratum of gas which floats over the surface of liquors undergoing the vinous fermentation in a brewery, and by pouring this water from one vessel to another, in order to encrease its surface, and thereby to hasten the impregnation. The *Duke de Chaulnes* has shewn how very large quantities of water may be impregnated very expeditiously with the gas of a brewery, by agitating the water immersed in the stra-

tum of gas. The agitation is performed by means of an inſtrument compoſed of many pieces of wood paſſing tranſverſely through a long axis, and ſimilar to the inſtrument uſed for frothing chocolate. This inſtrument being put into a tub filled with water to be impregnated, is to be turned quickly and alternately from right to left, and from left to right, and thus a ſtrong impregnation is ſaid to be given in a few minutes. The Duke recommends that conſiderable quantities of water ſhould be thus impregnated in great breweries, and put into large bottles well corked and waxed, in which it may be ſafely tranſported, and kept till it is uſed *.

Many

* The *Duke de Chaulnes* availed himſelf of the great quantities of this gas which is to be found in a brewery to exhibit, in preſence of the Academy of Sciences, ſeveral of its properties more at large than had been done before, at leaſt in *France*, where the ſubject is much more recently cultivated than in *England*, and he accompanied his experiments with a memoir on the phenomena produced by this gas, which will be printed in the next volume of *Memoires des Scavans Etrangers.*

The gas which he employed is that which floats on the ſurface of beer during its fermentation. He obſerves, that the atmoſphere of gas which riſes from this liquor fills all the upper part of the vat, in the bottom of which the beer ferments. The depth of the vat from its edge to the ſurface of the liquor was four feet, and this ſpace was filled with gas unmixed, or at leaſt, in a very ſmall degree, with air.

The *Duke de Chaulnes* plunged a jar into this ſtratum of gas, as one plunges a veſſel into the water contained in a baſon, and he withdrew it ſo full of gas, that a candle was extinguiſhed as ſoon as it came to be level with the edges of the jar. He then poured this gas into another jar of equal ſize, in the ſame manner as water or other liquors are poured from one veſſel into another. The gas deſcends by this eaſy operation from one jar to the other, ſo that a candle will now burn to the bottom of the firſt jar, and will be extinguiſhed as ſoon as it enters the ſecond. The greater gravity of the gas than of air is thus ſhewn in a ſtriking manner. Nothing can be more ſingular than this action of pouring from one veſſel into another, where nothing appears that is thus poured, and to ſee nevertheleſs a candle inſtantly become extinct, an animal die in a few ſeconds, and an alkali made to cryſtallize, when they are put into this ſecond jar, which does not ſeem to contain any thing.

He

Many other contrivances for the performance of particular experiments are described in the writings of Dr. Hales (*Statics*) Mr. Cavendish (*Philos. Trans.* 1766, 1767) Dr. Priestley (*Observations and Experiments on Air, three vols.*) and M. Lavoisier (*Opusculus physiques et chemiques, Vol. I.*)

He moistened the inner sides of a jar with oil of tartar per deliquium, and poured into this jar some gas. In less than a minute, these sides were covered with crystals.

By putting some caustic volatile alkali into a vessel filled with gas, and well closed, he produced a vacuum, as appeared from the fall of the mercury of a barometer, inserted into this vessel.

He filled large stone-ware bottles with this gas, by holding them during some time in the vat over the surface of fermenting liquor, and having corked the bottles, ordered them to be carried to the academy, in presence of whom he exhibited his experiments.

C O N-

CONTENTS.

A TREA-

A

TREATISE

ON THE

VARIOUS KINDS

OF

GAS.

CHAP. I.

Definition and Enumeration of Gaſes.

1. MOST, perhaps all, ſubſtances, ſolid and liquid, may, by heat, more or leſs intenſe, be converted into fluids exceedingly rare, inviſible, and highly elaſtic. Thus when water is expoſed to a heat ſufficient to raiſe the mercury in Fahrenheit's thermometer to 212°, if it be not ſubject to a greater preſſure than that of the atmoſphere, it becomes gradually changed into vapour, which is a fluid rare, inviſible, and highly elaſtic; and the water thus changed, while it continues expoſed to that temperature and preſſure, retains its elaſtic ſtate*.

Several

* Whenever the vapour of water becomes viſible, the water is no longer in the ſtate of vapour; but is again *condenſed*, that is, reduced to its original ſtate of a liquid; as is explained in §. 2. For fogs, and viſible exhalations, are nothing but aſſemblages of very minute drops of water formed by the condenſation of vapour; which drops are ſo ſmall that they can ſcarcely overcome the re-

ſiſtance

Several ſubſtances which were formerly thought unalterable by fire, have been lately diſcovered to be ſuſceptible of evaporation, when expoſed to a heat ſufficiently intenſe. *Diamonds* have been lately ſhewn by the French Academicians to be evaporable by a heat not much more intenſe than that uſed in the cupellation of ſilver. Gold and ſilver are ſaid to have been elevated by the heat of a concave mirror †.

2. Many of the ſubſtances thus volatilized, or converted into a rare, inviſible and elaſtic fluid, by heat, may be again condenſed into concrete, or palpable and viſible ſubſtances, by expoſing them to a heat leſs intenſe than that which was neceſſary to produce their evaporation. Thus when the vapour of water is expoſed to ſome degree of heat leſs than 212°, it loſes its great elaſticity, and bulk; and is again *condenſed*, that is, reduced to its original ſtate of a liquid. All thoſe rare, inviſible and elaſtic fluids which may, by cold, or ſuch a degree of it as has been hitherto applied, be thus condenſed, are called *vapours*.

3. Several other highly elaſtic, inviſible, rare fluids cannot, by the cold of the atmoſphere, or by any degree of cold to which they have hitherto been known to be expoſed, be thus condenſed. Such is the *air* which we breathe, and ſuch are the *elaſtic fluids*, which eſcape from wine and other fermenting liquors, and from the effervеſcing mixtures of acids and alkalies.

These

ſiſtance which the air makes to their deſcent, and therefore ſeem to be ſuſpended in that fluid. For their gravity being as their quantity of matter, and the reſiſtance of the air being as their ſurfaces, it follows, that the ſmaller the drops are, the more reſiſtance will be given to their deſcent through the atmoſphere.

† Buffon, Supplement, Tome 3me.

These *Fluids* are called *permanently elastic*, because they cannot, like those mentioned in §. 2, be deprived of their elasticity by cold *. They are also called Gas by *Van Helmont*, who discovered many of these permanently elastic fluids, and comprehended the whole genus of these fluids under this appellation; while he distinguished the several species, by adding descriptive epithets to the generical term; as *gas sylvestre, gas ventosum, gas flammeum*, &c. †

4. A Gas may therefore be *defined* "AN EXCEEDINGLY RARE, HIGHLY ELASTIC, INVISIBLE FLUID, NOT CONDENSABLE BY COLD."

By this definition a Gas may be distinguished from other substances. The elasticity of gases is so great, that they can support the weight of the incumbent atmosphere, and yet remain so rare, that although some are denser than others, yet they are all several hundred times lighter than water. They are distinguished from *smoke* and other *visible exhalations*, by their being invisible, and also by their great elasticity;

 and

* The Fluids called *permanently* elastic, may be fixed, absorbed, or deprived of their elasticity, by being combined with other substances. Thus the permanently elastic fluid obtained from calcareous earths, may be absorbed by water, or by the quicklime that is dissolved in lime-water; and when it is thus absorbed and combined, it is reduced to a space several hundred times less than that which it before occupied. And further, although these fluids retain their elasticity in any degree of cold to which they have been exposed, we cannot with certainty infer, that some of them might not be condensed by a more intense cold. The *permanency* of the elasticity, therefore, of these fluids is to be understood only as relative, 1st, to their uncombined state, and, 2dly, to any degree of cold to which they have hitherto been known to be exposed.

† See an enumeration of the principal gases observed by *Van Helmont*, in the preface to this Treatise.

and they are distinguished from *vapours*, by their not being condensable by cold.

5. The *various kinds of Gas* hitherto discovered, *native* or produced by *art*, are enumerated below. These shall be treated successively. Others will probably be discovered by means of future experiments and observations.

1. *Air.*
2. *Calcareous Gas.*
3. *Inflammable Gas.*
4. *Nitrous Gas.*
5. *Vitriolic acid Gas.*
6. *Marine acid Gas.*
7. *Nitrous acid Gas.*
8. *Fluor acid Gas.*
9. *Alkaline Gas.*

CHAP. II.

On Air.

6. *AIR* is the invisible, insipid, inodorous, pellucid, sonorous, respirable, and permanently elastic fluid that surrounds our Globe. From the permanency of elasticity, it is comprehended in the definition given (§. 4.) of Gases, of which it is therefore a species, and might be called *Atmospherical Gas*, in conformity with the mode which we have adopted of denoting the several species of permanently elastic fluids by descriptive epithets added to the generical word *Gas*; but the word *Air* having been immemorially applied to signify this fluid, we shall, in the following pages, employ it in this popular sense, and shall confine it to denote the atmospherical fluid alone. And when I shall have occasion to mention those re-

spirable

ſpirable and permanently elaſtic fluids which may be obtained by certain artificial proceſſes, and to which the ſame name cannot be denied, as they poſſeſs all the known properties of air, I ſhall diſtinguiſh them from the atmoſpherical fluid, by adding the epithet *factitious* to the word *air* ‡. Phyſical writers have treated copiouſly on the gravity, elaſticity, and other mechanical qualities of air. Its *chemical* properties have been diſcuſſed at the article *Air* of the *Dictionary of Chemiſtry*. Here therefore ſome ſupplemental obſervations only ſhall be added, concerning its *affections* by *different ſubſtances*, and its *conſtitution*.

7. Air is capable of *combining with various ſubſtances*. Hence the atmoſphere is replete with diverſe exhalations, and with all thoſe matters which the air can diſſolve: and its properties are affected by the quantity and kind of foreign particles contained in it.

8. *Water* is one of thoſe ſubſtances which *Air is capable of diſſolving*; and accordingly more or leſs of this liquid is always contained in the atmoſphere; as appears from the moiſture imbibed by dry cauſtic alkali

‡ The word *air* has been uſed by Mr. *Boyle*, Dr. *Hales*, Dr. *Black*, Mr. *Cavendiſh*, Dr. *Prieſtley*, and other Engliſh authors, to denote the whole genus of permanently elaſtic fluids, moſt of which differ widely, in their properties, from the atmoſpherical fluid. I have, in the preface, given my reaſons, for confining this word to its proper, antient and popular meaning, and for giving other names to the fluids which theſe authors have diſtinguiſhed by the terms, *fixed air*, *inflammable air*, *nitrous air*, &c. But to prevent any ambiguity that might ariſe from this difference of phraſeology, I have, in treating of each fluid, mentioned the names by which theſe authors have diſtinguiſhed it. Thus when they ſpeak of the fluid which is the ſubject of this chapter, they add to the word *Air*, (by which alone it is diſtinguiſhed in this Treatiſe) the epithets *common*, or, *reſpirable*.

alkali expofed to air, or from the condenfation of moifture on the external furface of a veffel in which artificial cold is produced by mixture of falt and fnow. Probably no part of the atmofphere is ever free from a portion of diffolved water, befides the watery particles that float *vifibly*, (for water diffolved in air is invifible) forming clouds, and fogs; all which are mechanically fufpended in the lighter atmofphere, as gold-leaf is in water, and not *chemically* combined with the air.

9. As water is capable of being diffolved by air, and thereby diffufed through the mafs of the atmofphere, fo alfo is *air capable of being abforbed by water*, and the air thus abforbed feems to lofe part of its elafticity. Thus if water be deprived by boiling of all the air or other Gas contained in it, and afterwards be expofed to the atmofphere, it will abforb fome air. And if a bubble of air be admitted into an inverted bottle filled with boiled water, the whole quantity of air will be abforbed, provided the bubble of air be not larger than is requifite to faturate the quantity of water employed*.

The quantity of air capable of being abforbed by a given quantity of water, is, according to Dr. *Hales*, equal in bulk to one fifty-fourth part, and according to *Nollet*, to one thirtieth part of the water employed†.

10. *Air*

* This abforption of air by water has been generally faid to occafion no fenfible encreafe of the bulk of the liquid. *Mufchenbroek* however obferves that the air abforbed by water does add a very *little* to the bulk of the water; but that any difference it may produce in the fpecific gravity of the liquid is fo fmall that it can fcarcely be difcovered by experiment. *Introd.* §. 1481.

† We need not wonder that a fubftance fo rare and elaftic as air fhould be thus united to water, and by the union be deprived of the greateft

10. *Air promotes the combuſtion of inflammable bodies;* and the air thus employed is *altered* by the operation. Thus when charcoal or other inflammable ſubſtance is burnt, the air in which this combuſtion happened, becomes poſſeſſed of properties very different from thoſe of common air,

11. *Air thus altered by burning ſubſtances becomes leſs in bulk* than it was before the alteration, as Mr. *Boyle* has obſerved. Thus, when lighted candles or other kindled ſubſtances are put under a receiver, the mouth of which is inverted and immerſed in a veſſel filled with water, they burn a little while, longer or ſhorter, according as the quantity of air is greater or leſs relatively to the quantity of ſubſtance actually in combuſtion at a time. When they have ceaſed to burn, the

greateſt part of its elaſticity; this phenomenon being conſentaneous with the general analogy of chemical ſolutions or combinations. For in all chemical ſolutions, the integrant parts of one body are divided and ſeparated by thoſe of the other component body. Thus the particles of air are ſeparated from each other by the particles of water. But elaſticity or expanſive force cannot be conſidered as the property of any ſingle particle, for it implies two particles, at leaſt, endeavouring to recede from each other. The particles therefore of air being conſiderably disjoined from each other, and engaged with thoſe of water, may have their expanſive power ſo much weakened, that they yield to the combining power of water. The elaſticity however of air abſorbed by water is not deſtroyed, but only diminiſhed; for by the application of heat, or by removing the preſſure of the atmoſphere, the air gradually recovers its expanſive force, and diſengages itſelf from the water. Thus *M. de Luc* obſerved, when he was making thermometers with different liquors, that theſe liquors which had been deprived by boiling of much of their contained Air or other Gas, did neverthelefs expand gradually, and riſe many degrees in the ſtems of the thermometers, when the preſſure of the atmoſphere was removed, and that this expanſion took place long before any bubbles appeared. See *Recherches ſur la modification de l'atmoſphere*, I. 230.

water within the receiver may be ſeen to riſe higher than it was before the combuſtion, as ſoon as the included air has loſt the heat which it had received from the burning ſubſtance. The greater height of the water within the receiver after the combuſtion, than before it, ſhews that the included air preſſes with leſs force on the ſurface of the water than the external air does; and conſequently that it is reduced to a ſmaller ſpace than it occupied before the combuſtion.

This *diminution of the preſſure*, or of the *bulk* of the quantity of air contained in the receiver, occaſioned by the combuſtion of inflammable ſubſtances, may depend upon a *diminution of the quantity* of this elaſtic fluid by *abſorption*, or by *precipitation* of part of it, or upon a *diminution merely of its elaſticity*, while the quantity remains the ſame. Dr. *Hales* conſiders it as a diminution of the elaſticity of the contained air: but Dr. *Prieſtley* is inclined to think, that it is a diminution of the quantity of air, ſome part being precipitated; and he is induced to form this opinion, from his not having been able to find any *conſiderable* alteration in the ſpecific gravity of the air in which candles or brimſtone had burnt. From ſeveral trials purpoſely made he thinks that this diminiſhed air was not heavier, but rather lighter than air which had not been diminiſhed. *Exp. and Obſ. on Air*, I. 46 *and* 267. II. 94.

Dr. *Hales* obſerved that the *air continued to diminiſh* under the receiver ſeveral days after the extinction of the candles. This continued diminution may probably have been occaſioned by a gradual abſorption of ſome part of the air by the water in which the inverted receiver was immerſed; for Dr. *Prieſtley* remarks, that "this diminution of air by burning is not always immediately apparent, till the air has paſſed ſeveral

"times

" times through water; and that when the experi-
" ment was made with veſſels ſtanding in quickſilver
" inſtead of water, the diminution was generally in-
" conſiderable till the air had paſſed through water."
Exper. and Obſerv. on Air, vol. I. 46.

Air altered by burning ſubſtances occaſions *a precipitation in lime-water.* It appears therefore that by combuſtion ſome Gas is produced which is capable of uniting with the quicklime diſſolved in the lime-water; and is probably the ſame which will be deſcribed in chap. 3d. under the name of *Calcareous Gas.* Whether this Gas proceeds from the combuſtible body employed, or from ſome precipitation of part of the air, or be a compound reſulting from the union of ſome part of the inflammable body with the air or any of its component parts, has not yet been aſcertained*. When this Gas has been abſorbed by water or by lime-water, the remaining part of the air is alſo noxious and unfit for maintaining flame.

Air diminiſhed by burning ſubſtances is no longer capable of maintaining fire. Dr. *Deſaguliers* obſerves that Air which had paſſed through burning coals into an exhauſted receiver immediately extinguiſhed flame.

Air is not capable of ſuffering more than a limited diminution by burning ſubſtances. The diminution of the bulk of a quantity of air included in a receiver in which a candle was allowed to burn as long as it could, was found by Dr. *Hales* to be equal to one twenty-ſixth part of the whole quantity of included air, and by Dr. *Mayow*

* This Gas cannot be produced from an inflammable body merely by heat without combuſtion; for when the focus of a burning glaſs was thrown on a bit of charcoal ſuſpended in a receiver filled with any other Gas than air, and inverted into a veſſel containing lime-water, no precipitation was occaſioned in the lime-water. *Exp. and Obſ.* I, 136.

Mayow to be one thirtieth, and by Dr. *Prieſtley* to be one fifteenth or one ſixteenth. This diminution is obſerved to vary in different circumſtances. Dr. *Hales* obſerved that air ſuffered a greater diminution in equal receivers by large, than by ſmall candles; and alſo with equal candles, in ſmall, than in large receivers. Probably the candles become extinct as ſoon as all the air in contact with, or near their flame, has ſuffered its alteration; for by other modes of combuſtion, the air has been made to ſuffer a much greater diminution. Thus Mr. *Cavendiſh* found that air was diminiſhed one tenth by paſſing through an iron tube filled with red-hot powder of charcoal. *Exp. and Obſ. vol. I.* 129.

And Dr. *Prieſtley* has diminiſhed the air much more by throwing the focus of a lens, or of a concave mirror, upon a bit of charcoal ſuſpended in a receiver. *Id. p.* 47.

I have produced a diminution equal to one ſixth part of the included air by making the candle while it burns move quickly through the different parts of the inverted receiver, and thereby bringing the flame into contact with more of the air, than when the candle remains in one ſituation till it becomes extinct.

12. *Air promotes the calcination of Metals*; and it is alſo diminiſhed by this operation, which is conſidered by Chemiſts as a ſpecies of ſlow combuſtion.

This diminution, like that effected by burning ſubſtances, *cannot be carried beyond a certain proportion to the whole quantity of air employed.* Accordingly, Father *Beccaria* found by expoſing filings of lead and tin to heat in veſſels hermetically ſealed, that only a part of theſe metals could be calcined, and that this part was proportionable to the capacity of the veſſels employed. [*Mem. de l'Acad. de Turin* 11.]

After

After the air has suffered its utmost diminution by calcining metals, it is no longer capable of promoting any further calcination.

The *diminution of Air by the calcination of metals* has been found by Dr. *Priestley* to be equal to one fourth of the whole quantity of air employed. Vol. I. p. 134.* But M. *Lavoisier* estimates this diminution only at one fifteenth or one sixteenth.

Air diminished by calcination differs from the air diminished by burning substances in this respect, that it *does not occasion a precipitation in lime-water*, the reason of which difference is assigned by Dr. *Priestley* to be, that the calx seizes the part of the air, which is precipitated, in preference to the lime. Vol. I. p. 136.

The water however over which metals have been calcined acquires a yellowish tinge, and an exceedingly pungent smell and taste, *Id.* 135.

13. *Metals acquire weight by calcination*, and the air which has assisted in this process, is thereby diminished. These facts seem to shew that something is absorbed during calcination by metals from the air †.

This absorption of air, or of some part of air, is further rendered probable from the elastic fluid that has

* This very great diminution of air was effected by throwing the focus of a burning mirror or lens upon bits of lead and tin suspended in a glass receiver.

† The first person who ascribed the acquisition of weight by calcining metals to the absorption of air was *Jean Rey*, who has written expresly on this subject, in a book entitled, *Essais de Jean Rey Docteur en Medicine, sur la recherche de la cause pour laquelle l'Etain et le plomb augmente de poids, quand on les calcine.* A Bazas 1630. This author attributes the encreafe of weight to the adhesion of the denser part of the air to the calxes, while the more subtile part of this fluid, which prevents the adhesion of the air to other substances, is separated during the calcination.

has been obſerved to eſcape during the reduction or revival of metallic calxes, and from the loſs of weight ſuſtained by them during that operation.

14. *Air* is *diminiſhed* by exhalations of *liver of ſulphur*, and of various *inflammable ſubſtances.*

Mr. *Boyle* relates that a quantity of *air was totally abſorbed by oil of turpentine* and *ſpirit of wine* mixed together. [*Boyle's works, vol. V. p.* 113.] Dr. *Prieſtley* has alſo found that oil of turpentine poſſeſſes the power of diminiſhing air in ſo great a degree, that in one experiment one fourth only, and in another experiment only one ſixth of the original quantity of air remained. *Vol. III. p.* 92. Dr. *Hales* found that air was abſorbed by the *pyrophorus of Homberg*; and Dr. *Prieſtley* obſerved that diminutions of air were occaſioned by *liver of ſulphur*; by a cement compoſed of *turpentine and bees wax*; by *white paint*; and by *red lead and oil.* Vol. II. p. 182.

Dr. *Hales* found that a mixture of *ſulphur and filings of iron* formed into a paſte with water diminiſhed air; and the diminution has been eſtimated by Dr. *Prieſtley* to be equal to one fourth or one fifth of the air employed. [*Exp. and Obſerv. vol. I. p.* 105.] This diminution was equal, whether the experiment was made over mercury or over water. The diminiſhed air was found to be lighter than pure air; and it did not precipitate lime-water; the cauſe of which has been attributed to the acid of the ſulphur diſſolving the lime, and thereby preventing its precipitation. [*Exp. and Obſerv. vol. I. p.* 105.]

15. *Air is diminiſhed by expoſure to putrefying ſubſtances.* At firſt an elaſtic fluid is frequently generated, by which the bulk of the air is encreaſed *, but in eight

* *See Chap. XI.*

eight or ten days, the air is reduced to about four fifths or five sixths of its original dimenſions. [*Id. vol. I. p.* 78.]

16. *Air is diminiſhed by reſpiration of animals*, as Mr. *Boyle* firſt obſerved. Vol. IV. p. 122. The diminution was found by Dr. *Hales* to be about one thirteenth of the whole air employed.

Air diminiſhed by reſpiration *precipitates the lime contained in the lime-water*, as Dr. *Macbride* obſerved.

17. Various other ſubſtances and mixtures have been obſerved to diminiſh air, among which are the following:

a. Lime mixed with *water. Hales.*

b. Lime mixed with *Sal Ammoniac. Hales.*

c. Lime mixed with *Acids. Hales.*

d. Marine acid extricated by pouring vitriolic acid on ſea-ſalt, or on ſal ammoniac. At firſt ſome fluid was generated, probably that which is treated of in Chap. VII. under the name of *Marine acid gas.*

e. Volatile alkali mixed with *iron. Hales.*

f. Volatile alkali mixed with *copper. Hales.*

g. Iron filings mixed with *water. Hales.* M. *Lavoiſier* found that the diminution of air by iron-filings and water amounted to one fourth part of the air in the ſpace of two months; and Dr. *Prieſtley* obſerved, that the air thus diminiſhed could not be further diminiſhed by nitrous gas. *Exp. and Obſ. vol. II. p.* 182.

h. Dr. *Hales* obſerved that air was diminiſhed in the *diſtillation of aqua-fortis*, and by the mixture of *aqua-fortis* with *copper ore*, or with *pyrites*, or with *coal.* And Dr. *Prieſtley* has found, that even the pure colourleſs nitrous acid vapour does, in length of time, phlogiſticate air.

i. Vo-

i. Volatile sal ammoniac during its sublimation. *Hales.*
k. Sulphur subliming. Hales.
l. Vinous Gas. Boyle III. 144. *See Chap. III.* §. 35.
m. Nitrous Gas. Hales. See Chap. V.

n. Electric sparks. The electric spark being made to pass through a quantity of air included in a glass tube, in which also was contained some water tinged blue with turnsole, diminished the air one fifth, and changed the blue colour of the liquid to a red. *Exp. and Obs. vol. I. p.* 184. When the electric spark was taken in air over lime-water, the lime was precipitated. *Id.* 186. And when the electric spark was taken in air and in a vessel containing some caustic vegetable alkali, the alkali became crystallized. *Rozier. Aug.* 1777.

o. Concentrated vinegar. Exp. and Obs. vol. II. p. 27.

p. Nitre, which has been melted, during its cooling, was observed by Dr. *Priestley* to injure common air. *Vol. II.* 167.

q. Vitriolic acid Gas was observed by Dr. *Priestley* to injure common air. *Vol. II.* 209. See Ch. VI.

r. Bolognian Phosphorus diminishes and phlogisticates air in a remarkable degree. But the *Phosphorus of Urine* produced this effect very slowly and in a small degree, as has been observed by *Signor Alexander Volta.* Exp. and Observ. vol. III. 381.

s. Air is diminished by *Diamonds* exposed to violent heat. M. *Lavoisier* observed that 60 cubic inches of air, in which four grains and a half of diamonds were exposed during 16 minutes to the focus of Tschirnhausen's great lens, suffered a diminution of eight cubic inches. The air thus diminished precipitated the lime contained in lime-water. *Mem. de l'Acad.*

des

des Sciences à Paris, 1772. This experiment, together with the flame observed in diamonds exposed to heat under a muffle, and the preservation of diamonds in the fire by inveloping them in powdered charcoal, seem to decide the question, lately agitated in France, in the affirmative, whether the effect of fire on diamonds be a real combustion. *See the Dictionary of Chemistry, article Diamonds.*

18. Air which has been once diminished to its utmost by any one of these processes cannot be further diminished by a repetition of that process, or by any of the other diminishing processes. *Exper. and Observat. vol. I.* 132.

19. Air may be *totally* and almost *instantaneously* absorbed by *charcoal* heated red-hot, or which has been heated red-hot, and extinguished without exposure to air in quicksilver. The quantity of air which may be thus absorbed or devoured is many times the bulk of the charcoal employed. The same effect is produced by charcoal, thus prepared, upon the other permanently elastic fluids. This very astonishing fact has been lately discovered by the *Abbé Fontana*, and communicated to me by Dr. *Priestley*. In order to repeat this experiment, let a jar partly filled with quicksilver and partly with air, or other elastic fluid, be inverted into a bason of quicksilver, and let pieces of charcoal, which have been previously made red-hot and extinguished in quicksilver, and which have not been exposed to air, be slipped under the jar, in which it will ascend through the quicksilver till it comes into contact with the air included in the jar, part or all of which air, according to its quantity relatively to the quantity of charcoal, will almost instantaneously disappear. The *Able Fontana* has made many experi-

experiments in consequence of this discovery, a relation of which, whenever he publishes them, cannot fail of being very interesting.

20. *Air is necessary to animal life*, as is well known from the fatal effects of enclosing animals in exhausted receivers, or in receivers filled with any other gas or vapour. Some insects however are said to live well in vacuo. *Muschenb. Introd. ad Phil. Nat.* §. 2167.

The air that has once served for the respiration of animals is unfit to be again respired, and is *fatal to life*. The *quantity* of air employed for respiration by a man is computed by Dr. *Hales* to be a *gallon* in every *minute*.

From the noxious quality of respired air, may we not explain the facts related by travellers, that animals are killed by the breath of whales, and especially by the breath of an immense serpent that inhabits the banks of the river Amazon *; the air respired by these very large creatures being sufficient totally to invelope smaller animals, and to exclude the air during a small portion of time, which, however, is sufficient for this noxious air to produce its fatal effect? If it be objected, that air, by having been respired only once, does not appear, from experiments hitherto made, to be so far vitiated, as to become capable of destroying life; may it not be answered, that the air, by being exposed to a much greater surface of lungs, and perhaps during a longer time, in these very large animals than in men, may probably suffer a much greater degree of injury, and be more completely phlogisticated? Perhaps also the effluvium and smell of the breath of these large animals may be peculiarly offensive to the organs of sensation of other animals, which

* See *Don Ulloa's Voyage.*

which they may affect in the ſame manner as the exhalations, deſcribed in §. 22. do when reſpired.

The more denſe the air is, the longer it is capable of ſuſtaining the life of animals, as appears from the experiments of Mr. *Boyle*. Nevertheleſs, a *rarefied air*, provided it be frequently renewed, ſuſtains life very well. *Condamine* lived ſeveral weeks upon the Peruvian mountains, where the air was ſo rare that the mercury of the barometer was no higher than fifteen inches and nine lines*. An *air* alſo *exceedingly denſe* may be with ſafety reſpired. Divers ſometimes breathe under bells an air nine times denſer than the air of the atmoſphere.

21. Not only the air diminiſhed by reſpiration is *noxious* to animals; but alſo the *air in which inflammable ſubſtances have burnt*; the air in which *hepar of ſulphur*, and *fumes of inflammable ſubſtances* have exhaled; the air in which ſubſtances have undergone the *putrefactive fermentation*, and probably all other kinds of *diminiſhed air*, are *noxious* to animal life †, *extinguiſh flame* †, and are incapable of *diminiſhing nitrous gas*, which is a diſtinguiſhing property of air.

C From

* See *Bouger's Voyage to Peru*.

† Nevertheleſs, Mr. *Boyle* obſerved that animals lived *nearly* as long in air in which candles had burnt, as in the ſame quantity of freſh air, and Dr. *Prieſtley* confirms the obſervation by his own experiments. Hence it appears that animals can bear a greater degree of depravity of air than is generally occaſioned by the burning of candles. But although flame be generally extinguiſhed when the air has ſuffered an inconſiderable diminution, yet by throwing the focus of ſolar rays on a bit of charcoal, the air may, by means of combuſtion thus promoted, be diminiſhed as much as it can by any other method, that is, one fifth of the whole quantity, as Dr. *Prieſtley* has ſhewn.——It cannot be doubted, that air thus diminiſhed as much as it can be by burning ſubſtances, is noxious and fatal to animal life. See §. 11.

From the many inftances of the diminution of air by combuftion, calcination and other proceffes, in which the phlogifton contained in bodies is fuppofed to be feparated from them, or merely by expofing air to phlogiftic vapours, it appears that the alteration produced in the air is effected by the phlogifton of thefe bodies combining with the air, or otherwife operating upon this fluid: and the air thus altered is accordingly called *phlogifticated air*. With this phlogifticated air is generally mixed a fmall portion of a gas which precipitates the lime contained in lime-water, and therefore feems to be the fame which will be defcribed in *chap.* III. under the name of *calcareous Gas*. And although in fome inftances, as in the calcination of metals, this gas does not appear, yet we cannot thence infer that it is not produced, becaufe it may be abforbed by the calcining metals, or other fubftances employed. *See* §. 11 *and* 12.

22. Almoft all exhalations, vapours, and fumes, when in confiderable quantity, make the air unfit for refpiration. The vapour of pure water threw a bird into great anxiety; the vapour of vinegar had the fame effect; vapour of fpirit of wine killed a bird; and the vapours of oil of turpentine, oil of olives and of fpirit of fal ammoniac, were alfo found to be fatal to life. *Mufchenb. Introd. ad Philof. Nat.* §. 2049. The vapour of newly plaftered walls and of granaries are known to be noxious. *Laghius* found that the fmell of camphor and of mufk was fatal to animals. *Comm. Bonon, tom.* 3. We fhall hereafter fee that every fpecies of Gas, air excepted, is noxious; and, they have been all obferved to be more fuddenly fatal than a vacuum is: hence, it is evident, that their noxious quality does not depend merely on their preventing the

the acceſs of air, or from their want of any principle, which may be ſuppoſed to render air neceſſary to life, but alſo from ſome inſtant and immediate effect on the organs of ſenſation. Animals may be rendered leſs ſenſible of the diſagreeable impreſſion, and leſs liable to be injured, by being gradually habituated to it, as Dr. *Prieſtley* has obſerved. *Exper. and Obſervat. vol. I.* 72.

23. Some attempts have been made to *reſtore vitiated air*, and render it again fit for reſpiration. Dr. *Hales* ſays that he cleanſed air, which had been reſpired, by making it paſs through flannel imbibed with ſalt of tartar; and that he prolonged the combuſtion of a candle in a given quantity of air by the ſame operation. The flannel employed gained weight, probably by abſorbing the calcareous gas which is produced by combuſtion or by reſpiration, as has been obſerved, §. 11 and 21. But as in air vitiated by reſpiration or by burning ſubſtances, not only this calcareous gas is noxious, but alſo the reſiduum after this gas has been ſeparated by being abſorbed in water, is found to extinguiſh flame, and to be incapable of ſuſtaining life, the above method of Dr. *Hales* cannot be very effectual. Dr. *Prieſtley* ſays, that by *long-continued agitation in water*, he has reſtored air vitiated by reſpiration, putrefaction, combuſtion, calcination of metals, a mixture of filings of iron with ſulphur, or by white paint. Was this melioration produced by the water ſeparating the vitiated part of the air from the reſt by abſorption; or by the agitation effecting a kind of circulation between the external air and the vitiated air included in the jars, by which means much of the former might be received into the veſſels, while part of the latter might

be abſorbed by the water and thrown out into the open air ‡?

The *Count de Saluces* pretends, that air injured by combuſtion can be meliorated by *cold* and by *compreſſion*. But Dr. *Prieſtley*, from experiments purpoſely made, has refuted that pretenſion. *Exp. and Obſ. vol. I.* 48.

24. *Air is neceſſary to vegetation* or the *life of plants*. In vacuo, plants do not grow, and ſeeds buried too deep under ground do not vegetate.

M. *Cygna* affirms that plants included in a given quantity of air diminiſh this fluid, and ſoon languiſh and die; and that if other plants be afterwards introduced into the ſame receiver, they preſently die without occaſioning a further diminution of the air. Nevertheleſs, it appears from Dr. *Prieſtley*'s experiments that plants can live long in confined air without ſenſibly diminiſhing or rendering the air unfit for maintaining flame or animal life. A ſprig of mint having been put into a glaſs jar inverted into a veſſel of water, during ſome months, the air was found not to be vitiated. *Exp. and Obſ. vol. I.* 5.

Dr. *Prieſtley* found that plants grew not only in confined air, but alſo in air vitiated by the flame of a candle, or by reſpiration: and even that the vitiated air was frequently reſtored, or at leaſt meliorated by the vegetation of the included plants. He put ſprigs of mint growing in water into different veſſels filled with air, in ſome of which candles had burnt till they ſpontaneouſly became extinct, and in others the contained air had been reſpired, and he found that after the plants had been growing a few days, the contained air was ſo much meliorated that candles burnt in it, and animals

‡ Dr. *Prieſtley* has found that pure air is conſiderably depraved by agitation in the pureſt water. *Vol. II.* 96.

animals could refpire it. (*Vol. I. p.* 51.) From thefe experiments he infers, that *vegetation is one of the means employed by nature to purify air tainted with refpiration, putrefaction, or combuftion* *.

But plants can tolerate only a certain degree of injury to the air in which they are placed; for Dr. *Prieftley* relates, that when growing fprigs of mint were put into air ftrongly and recently tainted with putrefaction, they *prefently died.* Vol. I. p. 86.

It is not however improbable that plants are capable of refifting a certain and even a confiderable degree of putrid taint infecting the air; for feveral kinds of plants and alfo animals are known to inhabit thofe places chiefly where a putrid effluvium prevails, which they fuftain without injury, and even perhaps with advantage

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* Dr. *Prieftley* has, fince his laft publication on air, been fo obliging as to acquaint me, that his late experiments confirm his opinion of the power of vegetation in purifying the atmofpherical fluid, although he acknowledges, with his ufual candour, that he has alfo met with many exceptions. He has not only meliorated phlogifticated air, by means of growing plants, but he has alfo, by the fame means, greatly encreafed the purity of atmofpherical air, fo as to make it approach to the ftate of the pure factitious airs defcribed in the following part of this chapter. Among the many difcoveries with which the labours of this zealous and fagacious philofopher are in a fingular manner crowned, one of the moft extraordinary is, that a green matter, which adheres to the fides of veffels filled with water, does, in a few hours after it is put under an inverted jar full of water, emit a confiderable quantity of *pure* air, like thofe airs obtained by factitious proceffes defcribed in the following part of this chapter. He has alfo found that the air contained in the bladders of feveral kinds of fea-weeds, while the plants are frefh, is confiderably better than atmofpherical air. In the *Epilobium hirfutum*, or the *Willow plant*, he has difcovered a fingular property which it poffeffes, namely, that of *abforbing* confiderable quantities of air, and of other permanently elaftic fluids.

to their peculiar conſtitutions. Further, animals and vegetables, while living, ſeem to poſſeſs ſome peculiar property of reſiſting putrefaction. For animals are known to live many days without food, and without any appearance of putrefaction, which however begins to take place a few hours after death. Alſo, vegetables are endowed with a ſimilar power; for the water in which plants grow, though it contain much vegetable putreſcent matter, does never putrify, while the plants live and are in health; but no ſooner is the life or the health of the plant deſtroyed, than the putrefaction begins. This fact is popularly known to perſons who keep ſprigs of mint, hyacinths or other flowers, growing in glaſs veſſels filled with water.

Hence the plants which grow in ſtagnant waters probably retard the corruption of theſe waters. *See Exp. and Obſerv. vol. II. p.* 185; where an inſtance is given of the water of a reſervoir becoming putrid, when the reſervoir was cleanſed from the vegetable matters which grew on its ſurface and its ſides, and did not recover its ſweetneſs till more vegetable matter again appeared.

Perhaps this important fact in animal and vegetable economy may be explained, by ſaying, that *fermenting* ſubſtances do generally aſſimilate to their own nature, in a certain degree, many other ſubſtances, with which they happen to be mixed; and that the fermentations which are continually proceeding in the fluids of living animals and vegetables, overcome the putrid or other noxious ferments, if theſe be not too ſtrong, in the ſame manner as the vinous fermentation reſiſts putrefaction, according to the experiments of Sir *John Pringle* and Dr. *Macbride*. Hence the more ſtrongly theſe natural fermentations proceed, that is,

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the more powerful is the *vis vitæ* of animals and plants, the more eaſily are noxious ferments overcome, and infections reſiſted.

The purification or melioration of the tainted air included in receivers in which growing plants were placed, may be attributed not only to the abſorption of the noxious vapour by the plants themſelves, but in ſome meaſure alſo, to the abſorption of this effluvium by the water in which the receiver was inverted, and more conſiderably by the watery vapours or perſpiration exhaled from the plant itſelf, which are known to be very great relatively to the ſmall ſpace within the receiver. Theſe vapours may be conſidered as water with an exceedingly enlarged ſurface, and therefore capable of producing its utmoſt effect by abſorption of the diffuſed noxious ſubſtance. The vitiated particles being thus abſorbed by the watery vapours floating in the receiver might have been precipitated when the vapours were condenſed by the evening colds; and by the conſtant ſucceſſion of evaporation and condenſation, which muſt have taken place in the receiver, the whole quantity of ſuch particles may have been abſorbed and precipitated, and the remaining air thereby purified.

While therefore we accede to the inference drawn by Dr. *Prieſtley* from his very curious experiments, that "VEGETATION is one of the means employed by "nature to purify air tainted by reſpiration, putrefac-"tion, or by combuſtion;" may we not aſcribe a conſiderable ſhare of this grand and important effect to EVAPORATION, whoſe operation is more extenſive, penetrates to greater heights, prevails on the middle of the ocean and in frozen regions where few vegetables appear; and may not plants be alſo conducive to this

effect in a great measure by exhaling vapours abundantly, and be, in this respect, considered as instruments of evaporation?

The vitiated particles in the air thus absorbed by the copious vapours which exhale from the surface of the earth and of the ocean, are raised along with these into the higher regions of the atmosphere, and thence again fall along with the condensed vapours or rain upon the earth. Thus diffused and united with water, perhaps resolved into their component parts, they are not hurtful to animals and vegetables, but enter probably along with the water into their vessels, combine with their fluids, and constitute part of their substance. From the animal and vegetable matters, these particles may be again expelled by various fermentations, putrefaction, and combustion; and thus, like most other kinds of matter, may undergo a perpetual circulation.

25. Several methods have been discovered by which *air*, or, at least, fluids possessing all the known properties of the atmospherical fluid, may be *produced by art.* For this important discovery, which leads to a knowledge of the constitution of the atmosphere, we are indebted to Dr. *Priestley*.

He found, that after he had absorbed by long-continued agitation in water as much as he could of the several kinds of gas, such as the inflammable gas, and that obtained by mixture of calcareous or alkaline substances with acids, (called by him and other Authors *fixed Air)* that the residuums had the properties of air, and he thence infers that *common air is thus generated* *. Exp. and Obs. vol. I. p. 40. 68.

26. By

* This inference seemed to me to be liable to two objections. 1. In the apparatus described for procuring these gases, there must always have been some small portion of common air mixed with the

26. By expofing *red lead*, or *calcined mercury*, to the focus of a burning glafs, Dr. *Prieftley* expelled from thefe fubftances a permanently elaftic fluid, which not only poffeffed all the known properties of atmofpherical air, but in which all thefe properties appeared in a more eminent degree than in the atmofpherical fluid

the gas. [*See Plate, fig.* 1.] 2. By a long-continued agitation of the gas in water expofed to the atmofphere, there would probably be fome particles of external air continually abforbed by the water, and afterwards feparated from the water into the veffel containing the gas. In order to obviate thefe objections, I procured fome gas from chalk and oil of vitriol, by means of an apparatus previoufly filled with boiled water, fo that no air could be mixed with the gas obtained; [*fee Plate, fig.* 2. *and explanation*;] and I let the gas remain expofed to a confiderable furface of clean boiled water till nine tenths were abforbed by the water, without agitation. I paffed this refiduum four times through lime-water, till it occafioned no more precipitation of the lime, by which operation, it was further reduced to a third, that is, to a 30th of its original quantity. This laft refiduum I found to be air fo pure, that a candle burned in it, and that it diminifhed as much nitrous gas as common air does. This production of air from calcareous and alkaline fubftances, is a very remarkable phenomenon, and deferves further inveftigation. I found that the refiduum of gas obtained from pot afh, and treated in the fame manner as I had done that from chalk, had the fame properties. The refiduum of a gas obtained by diftilling cream of tartar was chiefly inflammable, but feemed to contain fome portion alfo of air, for a fmall diminution was obferved upon mixing it with nitrous gas.

But air cannot be thus produced from every one of thofe gafes, which, from the property they poffefs of precipitating the lime contained in lime-water, have been confidered as of the fame kind with the gas obtained from calcareous and alkaline fubftances, and have been comprehended under the general name of *fixed Air*. At leaft, I found that a gas obtained by diftilling green vitriol, which extinguifhed flame, and precipitated the lime contained in lime-water, till it could no longer occafion any precipitation in lime-water, left a refiduum which extinguifhed flame, and did not in any degree diminifh nitrous gas, and was therefore fimilar in its properties to the fluid called *phlogifticated Air*.

fluid itſelf. For this factitious air did not only maintain the flame of kindled inflammable ſubſtances, but when a lighted candle or other ignited combuſtible ſubſtance was put into a veſſel containing this air, the flame was remarkably brighter, the combuſtion more rapidly excited, and a deflagration appeared ſimilar to that produced by thoſe mixtures of nitre and inflammable matters which are uſed in fire-works: Alſo, when animals were put into this factitious air, their reſpiration was much longer continued; that is, they could live much longer in a given quantity of it, than in atmoſpherical air. The diminution of nitrous gas (which is ſhewn to be a property of air, and to be an exact teſt of the purity of air, in *chap. V.*) was much greater; and the exploſion of inflammable gas much louder, by means of the factitious air, than when equal quantities of atmoſpherical air were mixed with theſe fluids. And the difference between the factitious and the atmoſpherical air appeared to be ſo great, that Dr. *Prieſtley* computes, that the former is capable of producing five or ſix times the effect of the latter fluid, in all theſe inſtances. He therefore conſiders this factitious fluid as a true and pure air, and thinks that the purity of the atmoſpherical air has been injured by the vapours with which it is always more or leſs mixed. He chiefly attributes the contamination of atmoſpherical air to the phlogiſton contained in the vapours mixed with the air, and the greater purity of the factitious fluid to the abſence of ſuch phlogiſtic vapours: accordingly, he diſtinguiſhes this factitious fluid and others of the ſame nature, which will be preſently deſcribed, by the name of *dephlogiſticated Air.*

27. The production of pure factitious air from red lead is much facilitated by addition of concentrated vitriolic acid. I put

I put 48 pennyweights of red lead into a long-necked retort, the contents of which were ten cubic inches; (*see Plate, fig.* 1. E.) and upon this red lead I poured twenty-four pennyweights of oil of vitriol. The red lead had been previously moistened with a little water, that the acid might more uniformly diffuse itself through the red lead. The nose of the retort was then immersed under water, and over it an inverted jar filled with water was placed. The mixture of red lead and vitriolic acid became very hot, and ten cubic inches of air were soon thrown into the jar, without the application of external heat. Upon applying the flame of a lamp to the bottom of the retort, more air passed copiously into the jars. The quantity of air expelled from the above mixture of vitriolic acid and red lead, was found to be 36 cubic inches, after the proper allowances for the air contained in the retort had been made. If we suppose this air to be of the same density as atmospherical air, we shall find that the weight of the air obtained is about one hundredth part of the weight of the red lead employed *.

28. A.

* In the first Edition of this Treatise, I said that a greater quantity of pure air might be obtained by adding vitriolic acid to red lead, than from an equal quantity of red lead alone, merely by violent heat. But Dr. *Priestley* has since been so obliging as to acquaint me, that he can produce as much air without addition of vitriolic acid as with it: which shews that the acid does not contribute to the formation of the air, as it seems to do in the instances of turbith mineral and other vitriolic salts, mentioned hereafter in §. 31. Nevertheless, the two processes of obtaining air from red lead with or without vitriolic acid, are very different, and are similar to the expulsion of calcareous gas, from calcareous substances by heat or by acids. For the expulsion of air from red lead is so much facilitated by addition of vitriolic acid, that much of the air escapes before any other heat is applied, than what arises from the mixture

28. A pure factitious air, possessed of all the known properties of atmospherical air, in a more eminent degree than the atmospherical fluid itself possesses these properties, and similar in all its effects to the factitious air above described, (§. 26.) may be copiously obtained by means of heat from *nitrous acid* mixed with almost any unphlogisticated earthy substance, as *minium*, *flowers of zinc*, *chalk*, *clay*, *gypsum*, *mag-*

mixture of these two substances, and the operation may be easily completed by the heat which glass vessels can sustain. The air thus produced (as in every other instance of the production of pure air) is always mixed with a very small portion of calcareous gas, and which may be separated by making the air pass through lime-water, or, more effectually, through water in which some pieces of quick-lime are put; for as soon as the gas uniting with the lime dissolved in the water precipitates this portion of lime, the water becomes capable of dissolving a fresh portion of the lime; and thus the water is always kept saturated with the lime, notwithstanding the precipitation produced in it. If pure factitious air should be hereafter applied to medicinal purposes, this method of obtaining it seems preferable to those hereafter mentioned by means of the nitrous acid; in which methods, not only a larger portion of calcareous gas is generally mixed with the pure air, but also considerable quantities of another noxious gas, namely, that which is described in chap. V. under the name of *nitrous*, are often produced, and which injure the purity of the factitious air. This method of obtaining pure air seems also to be preferable to those in which the air is expelled from red lead and other substances merely by heat, because these substances must be put into a gun-barrel, or other metallic vessel; and it is known that metals exposed to heat phlogisticate air, and sometimes emit a noxious inflammable gas. And when we consider that this pure factitious air, by whatever means it is obtained, is capable of producing five or six times the effect of atmospherical air in every instance in which air is known to exert its peculiar properties, it cannot be doubted, that the breathing of this air, during some longer or shorter time, must produce sensible effects in the animal economy. The investigation of these effects seems to be worthy of the attention of physicians.

magnesia alba, *wood ashes*, *flints*, and *Muscovy talc*, as Dr. *Priestley* has very happily discovered. *Vol. II. p.* 69, &c. He moistened any of the above-mentioned earthy substances with spirit of nitre, and put the substance thus moistened into a gun-barrel, or into a phial, into the neck of which was ground a bent glass tube. *See Plate*, *fig.* 1. C D B. He immersed the nose of the gun-barrel or of the glass tube into water, and placed over it an inverted jar filled with water. Upon applying heat to the part of the gun-barrel which contained the mixture, or to the bottom of the phial, an elastic fluid was expelled from the mixture and it passed into the inverted jar. By changing the jar frequently, he was able to examine the fluid expelled at different periods of the process. Thus he obtained from mixtures of each of the above-mentioned earthy substances with nitrous acid, considerable quantities of air, some part of which he found to be very pure, and other parts to be mixed with calcareous and with nitrous gas, described in *chap. III.* and *V.* In the further prosecution of his experiments he obtained this pure air, not only by moistening minium and flowers of zinc with nitrous acid, but also by treating all other *metallic earths* in the same manner; and he observed, that while these metallic and earthy matters contained any phlogiston, the gas obtained was chiefly nitrous; but that by continuing or repeating the process with more spirit of nitre, after the phlogistic matter had been expelled, pure air was copiously produced. The metals themselves, treated with nitrous acid, yielded, during their solution, nitrous gas, and afterwards pure air. When chalk, magnesia alba, wood ashes, or any of those substances are used, which contain calcareous gas, this gas must be previ-

previously expelled by the acid. And when any earth has been dephlogisticated and deprived of its gas, it may be used repeatedly, as long as it lasts, for the production of this air, by moistening it again and again with nitrous acid.

The *density* of this pure air was found by Dr. *Priestley* to be to that of atmospherical air, as 187 to 165. *Vol. II.* 94.

29. Pure air may be obtained from *nitre* alone by exposing it to violent heat in a gun-barrel. *Exper. and Obser. Vol. I.* 155.

30. A considerable quantity of pure air is extricated in the process for distilling acid of nitre from a mixture of nitre and vitriolic acid, or from a mixture of nitre and calcined martial vitriol. These operations must be performed in glass vessels, for if iron vessels are used, as is done by the distillers of aqua-fortis, nitrous gas is chiefly produced. From an ounce of pure nitre mixed with half an ounce of pure concentrated vitriolic acid, exposed to heat in glass vessels, I obtained, besides the usual quantity of nitrous acid, thirty ounce measures of pure air, after making proper allowances for the air previously contained in the apparatus. It did not appear that this air was mixed with either nitrous or calcareous gas.

From one ounce of nitre mixed with one ounce of calcined martial vitriol, I obtained 21 ounce measures of pure air, besides the usual quantity of nitrous acid.

But in the process for obtaining by distillation nitrous acid, with arsenic, according to *Stahl's* method, the whole quantity of the elastic fluid produced was nitrous gas. From one ounce of nitre mixed with 15 pennyweights of arsenic, I obtained, besides the nitrous acid, sixty ounce measures of nitrous gas.

31. Pure

31. Pure factitious air is obtained not only from the nitrous acid mixed with earthy and metallic subſtances, but alſo from compounds containing the *vitriolic acid.* Dr. *Prieſtley* obtained air from *alum* expoſed to heat in a gun-barrel. (*See Vol. I. p.* 155. And *Signor Landriani* has lately diſcovered that pure factitious air may be obtained by applying heat to *turbith mineral*, as Dr. *Prieſtley* has acquainted me. This experiment Dr. *Prieſtley* has not only verified, but he has alſo found that pure air may be obtained from other combinations of vitriolic acid with metallic ſubſtances, as from *vitriols* of *iron*, *copper*, and *zinc*.

32. Several *mineral ſubſtances* contain pure air, as Dr. *Prieſtley* has lately diſcovered. Among theſe ſubſtances are *Lapis calaminaris*, *Manganeſe*, and *Wolfram*. The relation of theſe diſcoveries cannot fail of making an intereſting part in his fourth volume of *experiments and obſervations.* That a ſmall quantity of air may be obtained from *ſedative ſalt*, he has mentioned in *Vol. II. p.* 86.

CHAP. III.

Of calcareous Gas.

33. FROM various ſubſtances hereafter mentioned a permanently elaſtic fluid may be obtained, whoſe diſtinguiſhing property is, that it is capable of uniting with the cauſtic calcareous earth or quicklime diſſolved in water, and of precipitating this earth from the water. Accordingly when a ſufficient quantity of it comes in contact with lime-water, the water is rendered of an opake white colour, and the ſmall particles of earth which produce this turbid

turbid appearance, gradually ſink to the bottom of the veſſel, leaving the water clear, and free from the earth which had been diſſolved in it; while the earth thus ſeparated from the water which had diſſolved it, is found to have recovered its ſolid form, and remains united and combined with the gas. Whatever gas therefore is obſerved to have this property of combining with the calcareous earth diſſolved in water, may be diſtinguiſhed from other elaſtic fluids by the name of *calcareous Gas*. Dr. *Hales* and his ſucceſſors have denominated this fluid, *fixed Air*; the impropriety of which term appears from conſidering, firſt, that this fluid is *fixed* only when it is combined with the calcareous earth or other ſubſtance; and that it is the reverſe of being fixed, that is to ſay, it is permanently elaſtic, whenever it is diſengaged; and ſecondly, that it does not poſſeſs the diſtinguiſhing properties of the fluid to which the word *air* has been immemorially aſſigned. Mr. *Bergman* of *Upſal* has given to this fluid the appellation of *Aerial acid*, which ſeems to imply that it is the acid conſtituent part of air, which doctrine has not been proved. It is called the *Mephitic acid*, by Mr. *Bewley*; and the *Mephytic gas* by Mr. *Macquer*, who at the ſame time acknowledges that this name is not ſufficiently characteriſtic. Neither of theſe appellations diſtinguiſh it from other gaſes, all which (excepting air) are mephytic or noxious to breathing animals, and ſeveral of which are equally or better entitled to the epithet *acid*, as *vitriolic acid gas*, *marine acid gas*, &c.

34. Calcareous gas may be obtained from a great variety of ſubſtances and by different proceſſes.

It may be extricated by *heat*, or by *acids* from all thoſe earths that are called *calcareous*, that is, all thoſe

those which by calcination may be converted into quicklime; such as *chalk*, *marble*, *lime-stone*, and *marine shells*; likewise from *fixed* and *volatile alkalies*; and from *magnesia alba*. Thus, if any of these substances be exposed to violent heat in a distilling apparatus of earthen or iron vessels, the gas that is extricated may be collected; or if acids be added to any of them, an effervescence immediately arises, which effervescence proceeds from a number of small bubbles of this gas that are expelled from these substances during their solution by the acids. If this effervescence be made in the apparatus represented in Fig. 1. C or E, the gas will pass into and be collected in the jars B or F.

The *quantity* of gas obtained from the above substances was found to be as follow:

108 grains of *crabs eyes* dissolved in one ounce and a half of distilled vinegar produced in vacuo 81 cubic inches of gas. *Boerhaave*.

One dram of *chalk* dissolved in two ounces of distilled vinegar produced 151 inches of gas in vacuo. *Boerhaave*.

Two drams of *crabs eyes* with one ounce of vinegar produced 12 cubic inches of gas. *Eller*, *Berlin Mem*.

Two drams of *crabs eyes* with one ounce of spirit of salt produced 75 cubic inches of gas. *Eller*.

Two drams of *red coral* with one ounce of spirit of salt produced 52 cubic inches of gas. *Eller*.

Magnesia contains half its weight of gas. *Black*, *Edinburgh Essays*.

Marble contains $\frac{407}{1000}$ parts of its weight of gas. *Cavendish*, *Phil. Trans.* 1776.

Lime-stone contains $\frac{13}{32}$ of its weight of gas, and $\frac{2}{32}$ of water. *Jacquin*, *Examen Doctrinæ Meyerianæ*.

Cremor calcis contains $\frac{13}{32}$ of its weight of gas. *Jacquin, ibid.* ‡

Chalk dried with the heat of boiling mercury contains $\frac{443}{1404}$ of its weight of gas. *Lavoisier, Opusc. Phys. tom. I.*

One dram of *salt of tartar* with half an ounce of spirit of nitre yielded 48 cubic inches of gas. *Eller.*

Crystals of salt of tartar yielded $\frac{428}{1000}$ of their weight of gas. *Cavendish.*

Crystals of soda yielded $\frac{576}{3615}$ of their weight of gas. *Lavoisier.*

Volatile

‡ The *cremor calcis*, or *cream of lime*, is the crust formed on the surface of lime-water exposed to the atmosphere, which crust falls to the bottom of the vessel, and a new crust is daily formed, till the whole of the quicklime dissolved in the water is precipitated. This crust is formed by the particles of calcareous gas which float in the atmosphere, uniting with the particles of quicklime at the surface of the lime-water. The earth thus combined with gas is restored to the same state in which it was before calcination, that is, of mild calcareous earth, which not being so soluble in water as quicklime is, crystallizes on the surface of the water; and this crystallized calcareous earth, or cream of lime, being heavier than the water, falls to the bottom; while new particles of the quicklime dissolved in the water, come into contact with the particles of gas floating in the atmosphere; and the process is repeated, till no more lime remains uncombined with gas in the water. But if the lime-water be exposed to evaporation, not only this mild calcareous crust will be formed in the manner above-mentioned, but also some of the quicklime, being deprived, by evaporation, of the water necessary to keep it dissolved, will be precipitated, and will mix with the cream of lime. Accordingly, M. *Bucquet* observed, that the powder precipitated from lime-water possessed the properties of quicklime. For when he distilled a mixture of this powder and sal ammoniac, he obtained *caustic* volatile alkali; whereas, if the powder had consisted entirely of the proper cream of lime, such as Mr. *Jacquin* had subjected to experiment, according to the above text, he would have obtained a mild volatile alkali.

Volatile ſal ammoniac yielded $\frac{528}{1000}$ of its weight of gas. *Cavendiſh.*

Volatile ſal ammoniac yielded $\frac{768}{1620}$ of its weight of gas. *Lavoiſier.*

35. This gas eſcapes abundantly from the juices of *fruits*, infuſion of *grains*, and of other *vegetable matters*, while they undergo the *vinous fermentation.*

The *quantity* of gas expelled from fermenting ſubſtances was firſt attempted to be aſcertained by Dr. *Hales.* From 42 cubic inches of beer, 639 cubic inches of gas eſcaped in ſeven days; and from 26 cubic inches of bruiſed apples, 968 cubic inches of gas were produced in 13 days. (*Hales's Analyſis.*) Mr. *Cavendiſh* found, that $\frac{57}{100}$ parts of dry ſugar were converted into gas by the vinous fermentation; and that the quantity produced from the fermenting juice of apples was equal to $\frac{381}{1000}$ parts of the dried juice.

Dr. *Prieſtley* tried how much gas could be extracted from different kinds of wines. From one ounce and a half of each of the undermentioned wines, he obtained the following quantities of gas.

Madeira - - - -	$\frac{1}{100}$	of an ounce meaſure.
Port, ſix years old -	$\frac{1}{48}$	ditto.
Hock, five years old -	$\frac{1}{24}$	ditto.
Barrelled claret - -	$\frac{1}{12}$	ditto.
Tokay, 16 years old -	$\frac{1}{20}$	ditto.
Champagne, two years old,	2	ditto.
Bottled Cyder, 12 years old,	$3\frac{1}{4}$	ditto.

Experiments and Obſervations, II. 227.

Much elaſtic fluid eſcapes from liquors undergoing the *acetous fermentation.* But whether this gas has the

the properties of calcareous gas, cannot be ſaid with certainty, as they have not been hitherto examined.

36. Calcareous gas is expelled from *animal* and *vegetable ſubſtances* undergoing the *putrefactive fermentation*. (See Chapter XI.)

37. This gas may be extracted from *animal* and *vegetable* matters by means of *heat*. (See Chap. XII.)

38. This gas is found in *mines*, and other *ſubterraneous* places, (*ſee Chap. XIII.*) and in many *waters*, eſpecially thoſe called *mineral*. (See Chap. XIV.)

39. This gas may be expelled from ſeveral *mineral ſubſtances* by heat. Thus, M. *Krenger* obtained, by diſtilling a *greeniſh fuſible ſpar*, that was luminous in the dark, a gas which united with and cryſtallized a ſolution of fixed alkali, which effects are produced by calcareous gas, as will be ſhewn. Alſo, Mr. *Woulſe* expelled the ſame gas by adding vitriolic acid to *ſpathoſe white ore of iron*, to *Somerſetſhire mangane ſe*, and to *Somerſetſhire white-lead ore*. (Philoſoph. Tranſact. vol. LXVI.)

40. Dr. *Prieſtley* has obtained this gas from ſeveral *ſaline* ſubſtances by means of heat, as from *green*, *blue* and *white vitriols*, *calcined alum*, *vitriolated tartar*, *borax*, and *white lead*. (Exper. and Obſerv. II. 112, &c.)

41. This gas is produced in the *revival of metallic calxes* by addition of *inflammable matter*, or by the *electric ſpark*. (Exper. and Obſerv. vol. II. 192.) From 144 grains of minium reduced by means of twelve grains of charcoal previouſly well burnt in a cloſe veſſel, M. *Lavoiſier* obtained, by expoſing the mixture to the focus of a lens, fourteen cubic inches of gas. (*Opuſc. Phyſ. I.* 258.)

42. This

42. This gas is produced during the *combuſtion* of every inflammable ſubſtance, excepting *ſulphur* and *metals*. See §. 11.

43. This gas is produced by making *electric ſparks* paſs through air. For if this experiment be made in a glaſs tube, the mouth of which is inverted and immerſed in lime-water, this liquor will be thereby rendered turbid. *Exper. and Obſerv. vol. I.* 186. *See alſo* §. 17. *n.*

44. Small portions of this gas are produced in the ſeveral *proceſſes for obtaining factitious* air. *See* §. 26, 27, 28.

45. This gas is produced abundantly from *nitre* deflagrated with any animal or vegetable inflammable matter. From one pennyweight of nitre and a pennyweight of powdered charcoal, mixed well with two ounces of clean ſand, to prevent the too haſty deflagration, and expoſed to heat in the retort, (*Fig.* 1. E.) I obtained 16 ounce meaſures of calcareous gas.

46. The *ſpecific gravity* of this gas was found by the Hon. Mr. *Cavendiſh*, to be to that of water as 1 to 511; or to that of air when this is 800 times lighter than water, as 157 to 100. According to Mr. *Lavoiſier*, the ſpecific gravity of this gas is to that of air as 561 to 455.

47. The *properties* of *calcareous earths* and of *alkalies are very much altered* by combination with this gas. For when *limeſtone* or other calcareous earths are, by calcination or otherwiſe, deprived of the gas uſually combined with them in their natural ſtate, they are thereby converted into *quicklime*. Alſo when *alkalies fixed* or *volatile* are deprived of their gas, by any means, they are thereby rendered more cauſtic, incapable of effervеſcing with acids and of cryſtallization, and

more powerfully solvent, as Dr. *Black* has proved by accurate and adequate experiments. *Edinb. Essays.*

The same excellent chemist has also shewn, that by recombining this gas with quicklime, magnesia, or alkalies, which had been previously deprived of it, their former weight and properties might be restored. From the greater acrimony communicated to quick-lime and to alkalies, by depriving them of their contained gas, he has distinguished them when thus deprived, or uncombined with gas, by the epithet *caustic*, as *caustic calcareous earth*, or *caustic fixed alkali*, or *caustic volatile alkali*; and when these earths or alkalies are combined with gas, he calls them *mild*.

Dr. *Black* contrived an apparatus, by which the gas extricated from an effervescing mixture could be conveyed into a caustic alkaline liquor, and shewed that by this method, the caustic alkali could be rendered mild, and could recover its effervescing and crystallizing properties. His apparatus consisted of two phials communicating by means of a bent tube, one end of which is inserted into the mouth of one phial, and the other end into the mouth of the other phial. In one of the phials he put some caustic spirit of sal ammoniac, and into the other phial he put some mild alkali or mild calcareous earth. Upon this mild alkali or earth he poured through a hole, purposely made in the side of the phial, some acid liquor, which immediately produced an effervescence as usual, that is, it extricated from the alkali or earth their contained gas. The gas being thus disengaged passed through the bent tube into the phial containing the spirit of sal ammoniac, with which it combined, and which it changed from a caustic to a mild state. For the spirit is by this process rendered capable of effervescing with acids,

acids, and if it be much concentrated, it will be feen to cryftallize during its impregnation with gas.

Dr. *Macbride* employed a fimilar apparatus to impregnate lime-water with gas, by which means he changed the cauftic earth or quicklime which was diffolved in the water to a mild calcareous earth, which not being foluble in water as quicklime is, was therefore precipitated. *See Macbride on the diffolvent power of Quicklime.*

48. Dr. *Black* has further determined by experiments the relative powers of the feveral alkaline fubftances to unite with this elaftic fluid, or the *affinities* of this fluid towards thefe fubftances. He found that this gas was more difpofed to unite with *cauftic calcareous earth* or *quicklime* than with any other fubftance; next with *fixed alkali*; then with *magnefia*, and laftly with *volatile alkali.*

Confequently mild volatile alkali may be deprived of its gas, or rendered cauftic, by applying to it magnefia previoufly deprived of its gas, or cauftic fixed alkali, or quicklime; and at the fame time the magnefia, fixed alkali, or quicklime, are thereby rendered mild. Magnefia alfo may be deprived of its gas by means of cauftic fixed alkali, or of quicklime; and laftly, mild fixed alkali may be rendered cauftic by means of quicklime, which is at the fame time rendered mild. Hence foap-boilers, in order to increafe the activity or diffolving power of their alkali, boil it in water with quicklime.

According then to this doctrine, the *caufticity* and other *peculiar properties* of *quicklime* and cauftic *alkalies*, are the *original properties* of thefe fubftances, while they are *pure* and *uncombined*; and are not communicated to them by any fuppofed abforption of matter from

the fire in calcination, as *Meyer* and other chemists maintain *.

49. This gas is capable of adhering to, or combining with, *metallic precipitates*. Thus when a mild alkali or calcareous earth is added to a solution of a metal in an acid, the alkali or earth unites with the acid, the metal is precipitated, and the gas of the alkali or earth, which would have occasioned an effervescence if the acid had not been united with a metal, does not in this case produce any effervescence, but unites with, and increases the weight of, the metallic precipitate. Dr. *Black*, who first observed the union of this fluid with metallic precipitates, attributes the fulminating property of *aurum fulminans* to the gas which adheres to the gold precipitated by a mild alkali. The adhesion of gas to metallic precipitates, is confirmed by M. *Lavoisier*. The

* This theory, which has been ably investigated, has thrown much light on many chemical phenomena. But although it is well supported by the decisive experiments related by Dr. *Black*, (*Edinburgh Essays*,) it has nevertheless met with much opposition from some German and French chemists, who adopt the theory of M. *Meyer*, concerning the principle which he called *Acidum pingue*, of which an account is given in the Dictionary of Chemistry. *See* Acidum pingue. On the other side, Dr. *Black*'s doctrine has been ably supported and confirmed by M. *Jacquin*, in a treatise called *Examen chemicum Doctrinæ Meyerianæ de Acido pingui et Blackianæ de aere fixo*. And this treatise has been attacked by M. *Crantz*, in his *Rectificatio Examinis chemici Doctrinæ Meyerianæ*, &c.

As not only the reasonings but also the facts related by these authors were contradictory, M. *Lavoisier*, of the Academy of Sciences at Paris, undertook a series of Experiments, with a view of ascertaining the several questions in dispute; an account of which he has published under the title of *Opuscules physiques & chymiques, vol. I.* These experiments, which seem to have been made with accuracy and ability, can leave no doubt of the validity of Dr. *Black*'s experiments and deductions.

The precipitation of ſome metallic ſolutions ſeems therefore to be effected by what chemiſts call a double affinity; that is, the gas of the alkali unites with the precipitated metal, while the acid unites with the alkali. Accordingly, the precipitation of ſome of theſe metals requires that the precipitating alkali be mild, that is united with gas. Thus, ſilver diſſolved in nitrous acid cannot be precipitated by a cauſtic volatile alkali, although it may very perfectly by a mild volatile alkali.

This gas not only aſſiſts the precipitation of metals from their acid menſtruums, when it is combined with alkalies, but even ſometimes effects this precipitation, without the aid of an alkali. At leaſt, there is one inſtance of ſuch precipitation, when this gas is added to a ſolution of ſugar of lead, as Mr. *Hey* of *Leeds* has obſerved. *See Appendix to Dr. Prieſtley's firſt volume of Obſervations and Experiments.*

50. This gas is capable of being *abſorbed by water*, and the water thus impregnated precipitates the lime from lime-water, as Dr. *Macbride* has ſhewn.

The quantity of gas which water at the temperature of 55° of *Fahrenheit*'s ſcale can abſorb, was found by Mr. *Cavendiſh* to be more than equal to the bulk of the liquid, and to be greateſt when the water was cold, and compreſſed by an heavy atmoſphere.

The water thus impregnated acquires a *ſubacid taſte*, like that of the mineral waters called *acidulous*, and it alſo acquires a *greater denſity*; the ſpecific gravity of diſtilled water impregnated with gas being to that of diſtilled water not impregnated, as 1000322 to 1000000, according to an experiment made by M. *Lavoiſier*, *Opuſc. Phyſ. & Chym. tom. I. p.* 210.

Gas

Gas absorbed by water may be thence expelled, by removing the pressure of the atmosphere from its surface by means of an air-pump; or by boiling the water, or by freezing the water. The greatest part of the gas escapes merely by exposure to the open air, especially in warm weather.

51. This gas is also capable of being absorbed by other liquors, as by *expressed oils* and by *spirit of wine*, which last liquor is found to be capable of absorbing $2\frac{1}{4}$ times its bulk of gas, when exposed to 46° of heat, according to *Fahrenheit*'s scale. *Mr. Cavendish, Phil. Trans.* 1766.

52. This gas *extinguishes flame*; and even a mixture of nine parts of air with one part of this gas does not admit a candle to burn, as Mr. *Cavendish* has observed, *Phil. Trans.* 1766.

53. This gas when respired is *fatal to animals.* Dr. *Priestley* however remarks, that insects and animals which breathe very little are stifled in this fluid, but are not soon killed; that butterflies and other flies generally become torpid and seemingly dead after being held a few minutes over a fermenting liquor; but revive on being brought into fresh air. *Exper. and Observ. vol. I. p.* 36. *Fishes* were killed by being put into water impregnated with this gas. *Id. vol. II. p.* 132. This gas is also fatal to *vegetable life.* Dr. *Priestley* observed that sprigs of mint growing in water were frequently killed in a day, or less, by being placed over a fermenting liquor. *Vol. I. p.* 36.

54. This gas *resists putrefaction*, as Dr. *Macbride* has proved from experiments. He shews, that by applying this gas to putrefying substances, their putrefaction is impeded; and he even pretends that they are hereby restored from a putrescent to a sound state.

He

He ſupports the opinion of Dr. *Hales*, that gas is the cementing principle of the particles of the ſolids and fluids in which it is contained, and that therefore when this is expelled, by fermentation, putrefaction, or otherwiſe, the coheſion of theſe particles muſt be diſſolved; and when it is reſtored, they may thereby recover their original conſtitution. But why is this gas conſidered as the cement or connective inſtrument more than any of the other principles which enter into the compoſition of theſe bodies? For by depriving a body of any of its conſtituent parts, the coheſion of the whole muſt be diſſolved, whether the principle thus taken away be gas, or earth, or acid, or alkali.

55. This gas when united with water is capable of *acting upon and diſſolving calcareous earth, magneſia, iron*, and perhaps ſome other metals. Mr. *Cavendiſh* firſt obſerved its property of diſſolving calcareous earths, and that although it at firſt precipitates the earth from lime-water, yet it afterwards re-diſſolves this earth. He has alſo ſhewn that the calcareous earth contained in *Rathbone-place* waters is kept diſſolved by no other menſtruum than this gas *. The ſame fluid is probably the ſolvent of the calcareous earth contained in all thoſe waters which depoſite their earthy ſediment upon expoſure to air.

Mr. *Lane* diſcovered that diſtilled water impregnated with the gas of fermenting or effervefcing ſubſtances was capable of diſſolving iron, and that the water thus impregnated with the gas and iron had a vinous ſmell and taſte, like thoſe of ſome chalybeate waters, in many of which he thinks the iron is diſſolved merely by means of gas. Hence a mild and pleaſant chalybeate water may be made, by putting filings of iron in water impregnated with the gas obtained from

* Phil. Tranſ. 1766, 1767.

from fermenting and effervescing substances. Not only iron in its metallic state, but also some of the *calciform ores of iron* may be dissolved in water impregnated with gas, as Mr. *Rouelle* found by experiment. *Lavoisier, Opuscules, I. p.* 156.

This gas occasions a *precipitation* in a solution of *sugar of lead*, as Mr. *Hey* of *Leeds* observes. (*Appendix to Dr. Priestley's first volume.*) This precipitate may be redissolved by adding nitrous acid.

56. The gas obtained from calcareous and alkaline substances, seems to suffer a decomposition when exposed to water. For, Mr. *Cavendish* observed, that some parts of it were much more easily absorbed than the rest; and that the residuum, which was about one fiftieth or one thirtieth part of the whole quantity, could not be more readily absorbed by water than air can. And Dr. *Priestley* found that the residuum which could not be absorbed by water had some of the properties of air, namely, that it effervesced with nitrous gas, (which is a test of air, as shall be hereafter shewn) and that it was not noxious to a mouse, although it was not so pure that a candle could burn in it. *See §. 25, and a note subjoined.*

57. Several circumstances concerning this gas lead to an opinion that it is of an *acid nature*, or that an acid enters into and predominates in its composition. Like other acids, it unites with alkalies, diminishes their causticity, and effects their crystallization. It dissolves calcareous earth and metallic substances, as iron and zinc. It has also been observed by Dr. *Bergman*, to alter the blue colour of the juice of tournesol to red. And lastly, it communicates an acidulous taste to water ‡.

Calcareous

‡ M. *Macquer* is inclined to believe that several of the singular effects, commonly attributed to air, especially those on the colours of

Calcareous gas has been discovered to possess considerable *medicinal* powers. Concerning its effects in the *scurvy*, and other *putrid* diseases, the *phthisis pulmonalis*, *ulcers*, *cancers*, and the *stone in the bladder*, see several valuable papers in the appendix to Dr. *Priestley's Experiments and Observations*; the writings of Dr. *Macbride*, Dr. *Percival*, and other late medical authors.

57*. Among the many extraordinary discoveries that have been lately made concerning the permanently elastic fluids, is that of Mr. *Achard* of *Bale*, who is said to have made true *crystals*, as hard and of the same shape as the native rock-crystals, by applying calcareous gas in a certain manner, and by a very slow operation, to some earthy matter.

CHAP. IV.
On inflammable Gases.

58. SOME gases are found to be capable of being inflamed. These are procured from very different matters, and by very different methods.

59. An inflammable gas is frequently found in *mines*, especially *coal-mines*, which sometimes takes fire, and explodes with great danger to the miners. *See Chap. XIII.*

60. Dr. *Hales* obtained an inflammable gas by distilling

o bodies, are caused by the calcareous gas, some portion of which, greater or smaller, is always mixed with the atmosphere. Such are, the blackness which black dyes acquire by exposure to air, the change of the green colour of a vat of indigo to a blue, the redness given to the liquor of the *murex*, the violet colour restored to the tincture of *orseille*, the weakening of many colours, bleaching, and other effects of exposing coloured bodies to the atmosphere. He thinks that light also may contribute to produce these singular effects. But he observes, that this subject is little understood, and he proposes to investigate it by further experiments.

ſtilling *wax*, *pitch*, *oyſter-ſhells*, *peaſe*, *amber*, and *coals*. *See Chap. XII.* Probably it might be obtained by applying heat ſuddenly to any *dry inflammable matter*, without excepting even the *inflammable* or *calcined metals*. Dr. *Prieſtley* procured inflammable gaſes from clean filings of *iron*, *zinc*, *braſs*, and *tin*, by expoſing theſe ſeparately to the focus of a burning lens in vacuo; and likewiſe from *iron filings* and *chalk*. *Vol. II. p.* 107, &c. But he could not procure any inflammable gas from *biſmuth*, *regulus of antimony*, *nickel*, *lead*, or *copper*; nor from *metallic calxes*.

61. An inflammable gas may be produced by diſſolving *iron*, *zinc* or *tin* in the *diluted vitriolic*, or *marine acids*.

According to experiments made by Mr. *Cavendiſh*, one ounce of zinc diſſolving in either of the above acids produced a quantity of inflammable gas equal in bulk to 356 ounces of water; one ounce of iron diſſolving in ſpirit of vitriol produced a quantity of gas equal in bulk to 412 ounces of water; and an ounce of tin produced as much gas as occupied the ſpace of 202 ounces of water. Dr. *Prieſtley* has produced an inflammable gas by diſſolving zinc and iron in radical vinegar; and by diſſolving copper, lead, and regulus of antimony in ſpirit of ſalt. *Vol. III. p.* 255, 256. The water over which this gas is contained becomes covered with a thin film, which is red, like ochre, if the gas has been procured from iron, and is white, if from zinc. *Vol. I.* 58.

62. *Marine acid gas*, (deſcribed in chap. VII.) or, the vapour of concentrated marine acid, may be *changed into an inflammable gas* by acting upon inflammable ſubſtances, as *ſpirit of wine*, *oil of olives*, *oil of turpentine*, *charcoal*, *phoſphorus*, *ſulphur*; and alſo upon *dry cork*,

cork, *oak*, *ivory*, *beef*, and even *flint*. (*Exp. and Obser- vol. I.* 149 *and* 232.) This marine acid gas being exposed to *quicklime* till $\frac{13}{14}$ were absorbed, the remainder was observed to be inflammable. *Id. vol. I. p.* 236.

63. An inflammable gas escapes from *putrefying animal or vegetable matters*. The waters of some *rivers* into which much fermentable matter is washed, as of the *Thames* and the *Aluta*, after having been confined during a certain time in casks, emit an inflammable gas. The surfaces of rivers are sometimes covered with an inflammable gas or vapour. *Exp. and Observ. vol. I. Appendix.* Inflammable vapours rise frequently from churchyards, houses of office, or from whatever places in which putrescent animal matters are collected.

Of the quantity of this gas which may be obtained from given quantities of putrefying matter, see Chap. XI.

64 An inflammable gas exhales from *liver of sulphur*, upon adding an acid, as *Meyer* and *Rouelle* have observed. (*Lavoisier, Opusc. Phys. tom. I.* 161.) The gas which is discharged from mixtures of sulphur with filings of iron, or zinc, is also found to be inflammable. *See Exp. and Observ. vol.* III. *p.* 259.

65. *Cygna* observes, that *air saturated with volatile alkali* is inflammable: and Dr. *Priestley* found, that *alkaline gas* was also inflammable.

66. Dr. *Priestley* observed, that the *electric spark* taken in oil, ether, spirit of wine, or spirit of sal ammoniac, produced an inflammable gas. *Exp. and Observ. vol.* I. 242. 245.

67. M. *de Lassone* has obtained inflammable gases by dissolving *zinc* and *iron* in *alkalies*. He discovered that liquid *volatile alkali* is capable of dissolving filings of

zinc,

zinc, and that, during the folution (which requires very little heat) an inflammable gas, capable of fulminating, when mixed with air, is expelled from the mixture, and may be collected by means of a proper apparatus.

He has alfo obtained a fimilar gas from the folution of filings of zinc by *cauftic fixed mineral alkali*, which was applied to the zinc in a liquid ftate, and was affifted by a boiling heat.

Filings of *iron*, although lefs foluble than thofe of zinc, by thefe alkalies, did neverthelefs yield a gas no lefs inflammable and detonating than the preceding. M. *de Laffone* could not diffolve either of thefe metals by means of a mild fixed alkali. He obferved however, during the boiling of this alkali in a liquid ftate with filings of thefe metals, that an elaftic fluid was produced, which was found (he fays) to be common air.

The folution of zinc, and of its flowers, by mild volatile alkali, produced ammonical filky falts, from which M. *de Laffone* obtained, by means of heat, a gas which was not inflammable, but poffeffed the properties of calcareous gas.

68. As *ether* has the fingular property of mixing with any permanently elaftic fluid, and expanding along with it; if therefore air be faturated with ether, an inflammable gas will be thereby formed. The effential oil or fpiritus rector of *fraxinella* feems to have a fimilar property of forming an inflammable compound, by mixing with air. For when this plant is in flower, the vapour which exhales from it may be kindled by a lighted candle.

69. Dr. *Prieftley* has fhewn, that an inflammable gas, which burns with a blue flame, may be obtained from

from the nitrous acid, acting upon *spirit of wine* or other inflammable substances, and that this gas is produced (together with the nitrous gas described in chap. V.) during the action of that acid upon *metals*, especially upon *zinc* and *tin*. He observed this inflammable gas also in the distillation of a solution of zinc in nitrous acid, in the period between the production of phlogisticated, and that of the pure factitious air described in §. 28. *Experiments and Observations, vol. III. p.* 24.

70. An inflammable vapour or gas was produced by repeatedly distilling the same *nitrous acid* from *quicklime*. Pott *on the solution of quicklime by nitrous acid*.

71. The inflammability of this was observed to be *greatest*, when the *distillation* of inflammable matter was *hastily performed*, and with a *heat suddenly raised*; or when the *solution of metals* in acids proceeded with the *greatest vehemence*, as when heat was applied, and acids of a proper strength were employed; and when the *putrefaction* of animal and vegetable matters were *hastily excited*. Exp. and Obs. I. 58.

72. The *specific gravity* of inflammable gas was found by Mr. *Cavendish* to be eleven times less than that of common air, when this is 800 times lighter than water.

73. The *mixture of air* is necessary to the inflammation of this gas, as of other inflammable substances. Mr. *Cavendish* has made experiments to discover the effects of firing different proportions of air, and the inflammable gas described in §. 61; and he found the following results:

A mixture of nine parts of air with one part of inflammable gas, did not fire easily, and the inflammation was accompanied with little sound.

Two parts of inflammable gas, and eight parts of air, were easily fired, and the sound produced was moderately loud.

Three parts of inflammable gas, and seven parts of air, gave a very loud sound.

Four parts of inflammable gas, and six parts of air, gave a sound very little louder than the former mixture.

Equal parts of gas and air, sounded like the last mixture.

In the first experiment, when nine parts of air were mixed with one part of gas, the flame spread gradually through the bottle containing the mixture. In the three next experiments, no light could be perceived, perhaps, because the flame lasted too short a time to make a sufficient impression on the eye. When equal parts of the two fluids were employed, a light was seen.

A mixture of six parts of inflammable gas, and four parts of air, produced a sound which was not loud, and after the explosion it continued to burn a short time.

A mixture of seven parts of inflammable gas with three parts of air, gave a gentle bounce, and continued to burn some seconds.

A mixture of eight parts of inflammable gas with two parts of air, caught fire without noise, and continued to burn only in the neck of the bottle.

From these experiments Mr. *Cavendish* infers, that unless the mixture contain more air than inflammable gas, the air is not sufficient to consume the whole of the gas, and that the remainder burns by means of air rushing into the bottle after the explosion ‡.

74. The

‡ The phenomena accompanying the inflammation of inflammable gas are well exhibited in the following experiment, related by

74. The *nitrous acid* in this, as in other instances, seems to supply the place of air in assisting the inflammation of this gas, as appears from some curious experiments of Dr. *Priestley. Experiments and Observations, vol.* III. *p.* 260.

He filled jars with nitrous acid, and inverted the jars so that their mouths were immersed in the same acid; he then displaced this acid, by throwing inflammable gas into the inverted jars. The gas which

by Mr. *Warltire. Appendix to Dr. Priestley's Exper. and Observ. vol. III. p.* 367.

"I have several times repeated an experiment with inflammable "air, that appears to me very curious. I fit a glass tube into a "tapering cork, and that to a round-bottomed phial, in such a "manner that a bend in the tube, when hung over the side of a "tub, be almost two inches under the water, but that the end "may rise four inches higher than the bend. The phial being "charged with the proper materials for producing inflammable air "briskly, it must be lighted, as it discharges from the end of the "tube, and will continue a flame as long as any inflammable air "rises, provided care is taken to prevent any moisture ascending "along with the inflammable air. The phial and its tube being "placed on the edge of the tub, a receiver, such as for an air-"pump, is to be brought over the burning air, and its edge "sunk in the water upon the bend of the tube. The inflamma-"ble air continues to burn as long as there is common air in the "receiver capable of supporting the flame. The appearances in "this experiment are very remarkable. About as much inflam-"mable air vanishes as is equal to the bulk of the common air; "the burning is attended with much heat and light; the common "air is contracted full one fifth part of its original dimensions; im-"mediately after the flame is extinguished, there appears through "almost the whole of the receiver, a fine powdery substance like "a whitish cloud, and the air in the glass is left perfectly noxious. "The bent tube should be slipped from under the receiver, the "instant the flame goes out, to prevent the inflammable air mix-"ing with the other air in the receiver."

had thus past through nitrous acid, was found to be more or less inflammable, (without mixture of air) and capable of producing an explosion, more or less loud, in proportion to the strength of the acid. He observed, that this gas remained inflammable a short time only after it had past through the acid; probably because the acid vapour was gradually deposited; and also that the gas lost its property of inflammability without mixture of air, by making it pass through water, in which case, the acid vapour is probably separated from the gas, by means of the water. *Experiments and Observations on Air, vol. III. p.* 260. *and vol. I. p.* 65.

75. The inflammable gases, which have been principally observed, *explode* during their inflammation, yet many others burn very well without explosion. Such are the inflammable gases extricated from a mixture of calx of zinc and charcoal, and from Prussian blue, by exposing these substances to heat in a gun-barrel, as M. *de Lassone* has observed. The detonation of inflammable gases may be prevented, as M. *de Lassone* affirms, by mixing them with nitrous gas: and Dr. *Priestley* observes, that if inflammable gas be mixed with nitrous gas, the mixture burns with a green flame. *Exp. and Observ. I.* 117.

75.* Inflammable gas may be kindled by the *electric spark*, even when the electricity is not very strong, as *Signor Alexander Volta* has observed. *Exp. and Observ. vol.* III. *Appendix*. M. *Chaussier* also shews, that inflammable gas may be kindled by electric sparks. For this purpose he filled a bladder with this gas, and made it pass from thence into the open air through a tube, at the extremity of which was a hollow copper ball pierced with one or more holes, through which the

the gas iſſued. By directing the ſpark to one or more of the holes, the gas, which mixed with air as ſoon as it iſſued, was immediately kindled, and continued to burn as long as the inflammable gas was preſſed out of the bladder. When the ball had only one hole, there was a ſtream of flame, like that of an enameller's lamp, by means of which M. *Chauſſier* melted metals, and revived metallic calxes without addition, the phlogiſton of the gas ſerving for the purpoſe of reduction: and he pretends, that metals may be melted with leſs heat, and in leſs time, by means of this flame, than of common fire. When a tapering hollow tube was ſubſtituted to the ball, ſo that the gas was made to iſſue through a ſmall hole in the point of this tube, no inflammation could be made to take place by applying electric ſparks, although the point was thereby rendered luminous. *Rozier's Journal, October* 1777.

Signor *Volta* thinks that the *ignes fatui*, which he ſuppoſes to be inflammable gas that has ariſen from marſhy grounds, and alſo that the *falling ſtars* may have been kindled by means of electricity.

75.** Meſſrs. *Macquer* and *De Montigny* have obſerved, that pure inflammable gas obtained from zinc and iron diſſolving in vitriolic acid, being applied to ſolutions of ſilver, mercury, lead, and other metals, communicated immediately to theſe ſolutions, the brown or black colour, which indicates the union of phlogiſton with metallic earths, and an approximation to reduction.

Theſe chemiſts have not aſcertained what change is produced upon the inflammable gas by this ſpecies of decompoſition, but they mean to inveſtigate this matter by further experiments. *Diction. de Chymie. Gas inflammable.*

76. Mr. *Cavendish* did *not* find that this gas was *absorbed by the water*, over the surface of which it stood: and it certainly may remain thus long without any considerable diminution. But Dr. *Priestley* says, that by agitation in boiled water, no less than three fourths of this gas may be absorbed, and that the remainder was but weakly inflammable. *Vol. I. p.* 67. And the inflammable gas, thus diminished by agitation in water, was found to have so far acquired the properties of air, that when it was mixed with nitrous gas, a considerable diminution was observed. *Id. vol. I.* 188.

77. Inflammable gas is *not diminished* by fumes of *liver of sulphur*, or by the *electric spark*. Neither did the electric spark passing through this gas change the colour of a solution of archil in water. *Exper. and Observ. vol. I.* 247. The effects of exposing this gas to *oil of turpentine* were remarkable. Its bulk was thereby considerably enlarged; it was rendered less inflammable; and it was made capable of diminishing nitrous gas nearly as much as air is. *Id. vol. III. p.* 366.

78. Inflammable gas is *noxious to animals*; but it does *not* seem to be *hurtful to vegetable life*; for Dr. *Priestley* found that plants grew pretty well several months in it, and that it still continued inflammable. *Vol. I.* 61.

C H A P. V.

On nitrous Gas.

79. DR. *Hales* obſerved, that when a mixture of nitrous acid with a martial pyrites was diſtilled; or when the nitrous acid was poured upon antimony, or mercury, or filings of ſteel, a gas was produced, which readily *united with air*, and produced *heat* by their union, while the mixture became *red* and *turbid*, and its quantity or *bulk* was found to be conſiderably *leſs* than the ſum of the quantities of the two fluids employed. *Statical Eſſays, vol. I.* 224. *and vol. II.* 280. Notwithſtanding theſe ſingular appearances, no further notice was taken of this gas, till Dr. *Prieſtley* thought it a ſubject worthy of his inveſtigation; and how ſucceſsfully he has proſecuted his inquiry, the following part of this chapter will evince. To this fluid he has given the name of *nitrous Air.*

80. Dr. *Prieſtley* has procured the ſame gas, by diſſolving in the nitrous acid any of the following metals, *iron*, *copper*, *mercury*, *ſilver*, *biſmuth*, and *nickel*, and alſo by diſſolving *gold* or *regulus of antimony* in aqua regia. He obtained little or no gas by diſſolving *lead* in nitrous acid; and he found that the gas produced by diſſolving *zinc* and *tin* in that acid, had the properties of the nitrous gas in a ſmall degree only. *Exper. and Obſerv. vol. I. p.* 110 *and* 126. *and vol. III. p.* 17. M. *de Laſſone* ſays, that the gas which he obtained, by diſſolving zinc in nitrous acid, was not *nitrous*, but *calcareous gas*.

81. Dr. *Prieſtley* has obtained this gas, by applying nitrous acid to almoſt all kinds of inflammable ſub-

ſtances, and more eſpecially to *vegetable* than to *animal* matters. Both theſe matters, thus treated with nitrous acid, yielded alſo conſiderable quantities of calcareous gas; but this difference was remarked between them, that vegetable matters yielded a much larger quantity of nitrous gas, and that the gas obtained from animal matters contained alſo a portion of a gas which is ſimilar in its properties to air in which candles had burnt till they became extinct, and which he therefore calls *phlogiſticated air*. This ſeems to eſtabliſh a new diſtinction between the animal and vegetable kingdoms. *Exp. and Obſerv. vol. II. p.* 145.

82. A large quantity of elaſtic fluid is expelled in the proceſs for making *nitrous ether* by diſtillation; and the *Duc d'Ayen* has found, that this fluid conſiſted of nitrous gas mixed with *ether*, which has the ſingular property of expanding into an elaſtic fluid when mixed with any kind of gas, as Dr. *Prieſtley* has obſerved. *Id. vol. I. p.* 252.

83. The ſingular phenomena which accompany the mixture of this gas with air have been mentioned in §. 79, namely, the *heat*, *redneſs*, *turbid appearance*, and *diminution of bulk*.

Dr. *Prieſtley* obſerves, that the diminution of a mixture of this gas and of common air is not an equal diminution of both the kinds, but (ſays he) "of about "one fifth of the common air and as much of the *nitrous air* as is neceſſary to produce that effect; which, "as I have found by many trials, is about one third "as much as the original quantity of common air. "For if one meaſure of nitrous air be put to two meaſures of common air, in a few minutes (by which "time the efferveſcence will be over, and the mixture "will have recovered its tranſparency) there will want

"about

"about one ninth of the original two meafures; and "if both the kinds of air be very pure, the diminu-"tion will go on very flowly, till, in a day or two, "there will remain one fifth lefs than the original "quantity of common air." *Exp. and Obferv. vol. I. p.* 110.*

When air is once faturated with the nitrous gas, any further addition of gas occafions an equal encreafe of the bulk of the mixture, and produces no heat or rednefs.

The nitrous gas fuffers no diminution upon being mixed with any other kind of gas than air, and confequently the diminution is greater when the air is purer, as Dr. *Prieftley* has obferved. And he has accordingly very happily applied this nitrous gas, as a teft, to *diftinguifh* air from other kinds of gas, and to *meafure the purity of air*; by which means we are furnifhed with a new method of examining air, and confequently of extending our knowledge of the atmofpherical fluid.

In order to examine or afcertain the purity of any kind of air, let a jar Y *(fee Plate and explanation)* be filled with water, and inverted into a veffel of water. Into this jar pour two meafures of the air to be tried, and one meafure of nitrous gas. If, when the effervefcence is over, and the mixture has loft its turbid appearance, the quantity remaining be only one meafure and feven ninths of a meafure, we may know that the air is as pure at leaft, as the air appeared to be in

* M. *Lavoifier* concludes from his experiments, that the proportion of air and nitrous gas requifite to produce a faturation, is 16 parts of the former to 7 1/3 parts of the latter; and that, when this proportion is obferved, the whole quantity of nitrous gas difappears, and alfo one fourth of the air employed.

in the trials made by Dr. *Prieſtley*, from which he deduced the rule above quoted. If the quantity of the remaining mixture be greater than $1\frac{7}{9}$ meaſures, then the air is known to be proportionably leſs pure. But if, upon adding another meaſure of nitrous gas, a further diminution takes place, that is, if the quantity of the remaining mixture be leſs than $2\frac{1}{9}$ meaſures, the air will be known to be purer in proportion to the further diminution that may be produced by adding more nitrous gas. Accordingly, when pure factitious air (§. 26, 27, 28.) is ſubjected to this mode of trial, four, five, or even ſix times the above-mentioned quantity of nitrous gas may be added to this pure air, before any augmentation happens of the bulk of the air employed.

This mode of trial may be applied to diſcover the ſtate and ſalubrity of air in different places and in different times. *Exper. and Obſervat. vol. I. p.* 116. Accordingly *Signor Landriani*, in a tour he lately made through *Italy*, examined, by this method, the ſtate of the air, with regard to its purity, in the different places through which he paſſed, and he found that the reſult of his experiments correſponded exactly with the opinion which generally prevailed among the inhabitants concerning the ſalubrity of the air. In the mountains near *Piſa*, he found that the air was more and more pure, as he aſcended higher; and that at *Mount Veſuvius*, the air was more vitiated, as it approached the ſummit. The air of the *Pontine lakes*, that of the *Scirocco* at *Rome*, that of the *Campagna Romana*, of the *Grotta dei Cani*, of the *Zolſatara* at *Naples*, of the Baths of Nero at *Baia*, of the ſea-coaſt of *Tuſcany*, were all found, on examination, to be ſuch as daily experience had led him to expect.

84. This

84. This gas *extinguishes flame*, (Hales, Appendix) and it is *noxious to animals*. But frogs and snails were observed to live in it a considerable time, although they at length died in it. *Exper. and Observ. vol. I. p.* 119. 226.

85. This gas is capable of being *absorbed* by various *liquors*, and in various proportions.

Distilled *water absorbs* about one tenth of its bulk of this gas; and the water thereby acquires an acid taste, and becomes covered with a film. Nitrous gas* was by long *agitation* in water rendered capable of being *diminished by fresh nitrous gas*, as air is; and when by this agitation it was reduced to one eighteenth of its original bulk, a mouse could live in it. *Exp. and Observ. I.* 189. 120.

Nitrous gas was very suddenly and copiously *absorbed* by *spirit of nitre*; the colour of which was thereby changed first to a deep orange, then to a green. The quantity of gas absorbed by a strong spirit of nitre was in bulk 650 times greater than the quantity of spirit employed. Towards the end of the process, the evaporation of the acid spirit was observed to be so very great, that, at last, only half the quantity of spirit remained, and this was further observed to be very weak. The absorption of the gas seems to have rendered the spirit very volatile. *Exper. and Observ. vol. III.* 122, &c.

Oil

* Mr. *Bewly* remarks, that this gas does not give to water a sensible acid impregnation, unless it comes into contact, or is mixed with a portion of air. *Exper. and Observ. I.* 318. Neither does it seem to possess any of the properties of acids, while it retains its elastic state. The *Duke de Chaulnes* introduced some tincture of tournesol into a vessel containing nitrous gas, and observed, that no alteration was produced in the colour of the liquor.

Oil of vitriol was obſerved to abſorb about as much of this gas as water does; and to be thereby rendered of a purple colour. *Id.* III. 129.

Spirit of ſalt imbibed one twentieth of its bulk of this gas, and its colour was thereby changed from yellow to a ſky-blue. *Id.* III. 129.

This gas was alſo abſorbed by concentrated *vegetable acids.* Id. III. 130.

Nitrous gas has been obſerved by Dr. *Prieſtley* to be capable of being abſorbed by *oils*, *ether*, *ſpirit of wine*, and by *cauſtic alkali.* The quantity abſorbed by oil of turpentine was conſiderable, being equal in bulk to eleven times the quantity of oil employed. The whole of a given quantity of gas however could not be thus abſorbed; for a reſiduum, which extinguiſhed a candle and ſeemed to be like air which had been expoſed to burning ſubſtances, remained equal to one fourth of the quantity of gas expoſed to the oil of turpentine. *Exper. and Obſerv. vol. III. p.* 112, &c.

86. Nitrous gas being expoſed to a large ſurface of *iron* during two months, was rendered *capable of maintaining flame*, and even enlarging the flame, although it continued highly noxious. The ſame effects were produced by expoſing nitrous gas to *liver of ſulphur*, during twenty-four hours; (*Exper. and Obſerv. I.* 216, 217. *II.* 178.) and to a mixture of filings of iron and ſulphur. *Id. III.* 141.

A gas, poſſeſſed of this inflammable property, may be procured by diſſolving tin or zinc in nitrous acid. It may alſo be obtained by applying heat to a ſolution of iron in that acid, after the common nitrous gas had eſcaped from it during the ſolution, without heat. *Id. III.* 133, &c.

Nitrous

Nitrous gas was diminiſhed, by expoſure to *iron-filings and ſulphur* made into a paſte with water, to one fourth of its original dimenſions. When it has been thus diminiſhed by iron-filings and ſulphur, the reſiduum cannot be diminiſhed by air, nor by agitation in water. *Id.* I. 223.

87. The *electric ſpark* taken in nitrous gas diminiſhed this gas to about one fourth of its original quantity, and rendered it unfit for diminiſhing air. When this ſpark was taken while the gas was in contact with a ſolution of archil in water, the colour of this ſolution was changed from blue to red, in a very great degree. *Exper. and Obſerv. vol.* I. 122. II. 238.

88. Nitrous gas is quickly decompoſed by a ſolution of *green vitriol* in water; the colour of which is thereby rendered darker, but is reſtored to green, on expoſing the ſolution to air. *Exper. and Obſerv.* III. *Preface, p.* 33.

89. The *denſity* of nitrous gas appeared by an experiment of Dr. *Prieſtley* to be to that of air, as 184 to 185. *Exper. and Obſerv. vol.* II. *p.* 94.

90. Dr. *Prieſtley* thinks that this gas conſiſts of the vapour of the nitrous acid united with phlogiſton, together perhaps with ſome ſmall portion of metallic calx. *Exper. and Obſerv. vol.* I. *p.* 271.

And Mr. *Bewley* juſtly remarks, that this nitrous acid in form of a fluid, not condenſable by cold, cannot be reſtored to a liquid ſtate without the preſence and admixture of air. *Exper. and Obſerv.* I. *Append.* 318.

The red appearance therefore which takes place upon mixing nitrous gas with air, ſeems to proceed from the many ſmall particles or minute drops of nitrous acid juſt reduced from an elaſtic ſtate to that

of

of a liquid, in consequence of the mixture of this gas with air; and these particles gradually subside, or are absorbed by the water, and disappear.

CHAP. VI.

On vitriolic acid Gas.

91. THE *vitriolic acid* is capable of being raised by means of heat, and of mixture with *oils*, *charcoal*, or other *inflammable substance*, into an elastic fluid, which is not condensable by cold, as Dr. *Priestley* has discovered. *Exper. and Observ. vol. II. p.* 7. This elastic fluid is called by Dr. *Priestley*, who first observed it, *Vitriolic acid air.*

92. This gas is very readily *absorbed by water*; when thus brought into the form of a liquid, it possesses all the properties of the vitriolic, or rather perhaps of the volatile vitriolic or sulphureous acid. As this gas so readily unites with water, it therefore cannot be collected in vessels filled with this liquid, but with some fluid on which it has no action, as mercury.

93. The same kind of gas may also be obtained by means of heat from concentrated vitriolic acid and several *metallic substances*, as copper, silver, lead, iron and zinc. It has been already observed, that a gas of a different kind may be obtained from the same acid in a dilute state acting upon some of these metals. *See Chap. IV. on inflammable gas.*

94. The following *properties* of this gas were observed by Dr. *Priestley*. Exper. and Observ. vol. II. p. 7, &c.

a. It was *heavier than air.*

b. It *extinguished flame.*

c. It

c. It was *absorbed by charcoal,* to which it communicated a very pungent smell.

d. It *dissolved camphor* readily, and reduced it to a transparent liquor, from which, by addition of water, camphor was reproduced.

e. It did *not act* upon iron, nitre, common salt, or sal ammoniac.

f. It formed a *white cloud* upon being mixed with a vapour of *volatile alkali.*

g. It *injured common air.*

h. When *electric sparks* were passed through this gas, included by means of quicksilver, in a glass tube, the sides of the tube became tinged with a black stain *.

CHAP. VII.

On marine acid Gas.

95. CHEMISTS have remarked, that a considerable quantity of elastic fluid is disengaged during the distillation of spirit of salt by means of oil of vitriol, by which means much of the strongest acid escapes; and Mr. *Woulfe,* (Phil. Trans. vol. LVII.) in order to prevent this loss, has invented an apparatus, by means of which the vapour is made to pass repeatedly through water, and is thereby condensed; but this fluid was considered as a mere vapour, condensable by cold. Mr. *Cavendish* however, in attempting to produce an inflammable gas from marine acid acting on copper, in the same manner as he had done from

* The same stain is produced when the electric spark, and more effectually when the electric shock is made to pass through common air confined by quicksilver. This black matter, when heated, appears to be pure quicksilver. *Exp. and Obser. vol. III. Pref. p.* 34.

from that acid acting on iron and zinc, found that an inflammable gas could not be thus obtained; but from the phenomena accompanying the experiment was led to think, that some elastic fluid had been formed in the operation, and had been condensed as soon as it had come into contact with water. *Phil. Transf. vol. LVI.* This appearance of an elastic fluid that was condensed by contact with water, seemed to Dr. *Priestley* to be an object worthy of investigation, and from the experiments which he made with this view, he discovered a new species of gases; namely, that to which the epithet *acid* is given. He discovered that a gas could be obtained not only from spirit of salt acting upon copper, but also from that acid alone by means of heat; that this gas was quickly absorbed by water, but when collected in jars previously filled with quicksilver, that it retained its elasticity, and was therefore, according to our definition, a true permanent gas; to which he gave the appellation of *marine acid air*. Exper. and Observ. vol. I. p. 143.

96. The water which has absorbed this gas, becomes a *spirit of salt*, more or less strong in proportion to the quantity of gas absorbed, and thus a stronger marine acid spirit may be obtained than by any other method. *Exper. and Observ. vol. I. p.* 148. *Ice* is as quickly dissolved by this acid gas, as it is by a hot fire. *Id. vol. I. p.* 240.

97. This gas *acts upon* many *metallic* and *inflammable substances*, and is thereby changed into an *inflammable gas*, as is shewn in chap. IV. §. 62. But the fumes of *liver of sulphur* did not render it inflammable: these fumes reduced its dimensions to one half. *Exper. and Observ. vol. I. p.* 235.

Marine

Marine acid gas was a little diminiſhed by the *electric ſpark* paſſing through it. *Exp. and Obſerv. vol. II. p.* 239.

98. This gas *extinguiſhes flame*; and when mixed with air, it gives to flame a beautiful green or bluiſh colour. *Id. I.* 147.

CHAP. VIII.

On nitrous acid Gas.

99. NOT only the nitrous gas above deſcribed (chap. V.) may be obtained from the nitrous acid; but alſo the mere vapour of heated ſpirit of nitre was diſcovered by Dr. *Prieſtley* to aſſume the form of gas: at leaſt, it remained uncondenſed by the cold of the atmoſphere to which it was expoſed. *Exper. and Obſerv. vol. II. p.* 169.

The difficulty of finding a fluid capable of confining this vapour, and on which it has no action, prevented a complete inveſtigation of it: for it was readily abſorbed by water, and it diſſolved quickſilver. Our knowledge of it is therefore very imperfect; but if it ſhould be found, upon further examination, to be a permanent gas, it may be denominated *nitrous acid gas*; while the gas deſcribed in chap. V. may retain the name of *nitrous gas*.

When this vapour was mixed with nitrous gas, the mixture became red and turbid, the nitrous gas was diminiſhed, and its power of diminiſhing air was leſſened. *Exper. and Obſerv.* II. 170.

Dr. *Prieſtley*, to whom we are indebted for every thing we know concerning this gas, not finding any vapour in the ſtate of liquor capable of containing it,

made it paſs from the veſſel containing nitrous acid acting upon metals, into phials containing air, by which means the phials were filled with this vapour mixed with air. The vapour in theſe phials was obſerved to be red; and the intenſity of the red colour of this vapour, and alſo of the high-coloured ſpirit of nitre itſelf, was encreaſed by heat. This phenomenon Dr. *Prieſtley* attributes to the action of heat on the phlogiſton contained in the vapour and acid.

This vapour being mixed with air, and afterwards ſeparated from the air by being abſorbed by water, was found to have ſo altered the air, that it was no longer capable of diminiſhing nitrous gas. *Exp. and Obſerv. vol.* III. *p.* 192.

Water very readily abſorbs this vapour, and is thereby converted into a ſpirit of nitre, the colour of which varied according to the ſtrength of the impregnation, from blue to green, and thence to a yellowiſh hue. *Id.* III. 198.

During the beginning of the impregnation of the water with this nitrous acid vapour, the water was obſerved to ſparkle much; and the impregnated water gradually emitted ſo much elaſtic fluid during two or three days after the impregnation, that the veſſels, if cloſely ſtopt, were in danger of burſting. This elaſtic fluid was expelled more copiouſly by heat; and upon examination, was found to be *nitrous gas*. The quantity of this gas which was expelled from impregnated water, was in bulk ten times greater than the water employed. But it appears from Dr. *Prieſtley*'s former experiments, that water can abſorb only one tenth of its bulk of nitrous gas; therefore this large quantity of nitrous gas does not enter as nitrous gas mixed with the acid vapour into the water; but

ſeems

ſeems to be formed by the union of the vapour with the water.

This acid vapour, united with expreſſed oils, rendered them of blue and yellow colours, and coagulated them. By combining with eſſential oils, it produced heat and effervescence; and once an exploſion happened. *Exper. and Obſerv.* III. 208. 210.

The gas produced by the union of the vapour with oils, was found to be ſimilar in its properties to phlogiſticated air, or air which had been expoſed to burning or phlogiſtic bodies; that is, it extinguiſhed flame, and poſſeſſed none of the diſtinguiſhing properties of other gaſes. *Id.* III. 211.

Oil of vitriol and ſpirit of ſalt imbibed this acid vapour. The ſpirit of ſalt thus impregnated became an aqua regia, which readily diſſolved gold; and when heated, it yielded a conſiderable quantity of nitrous gas, in the ſame manner as the impregnated water was obſerved to do. But no gas could be expelled from the impregnated oil of vitriol. *Id.* 222.

CHAP. IX.

On fluor acid Gas.

100. DR. *Prieſtley* has obtained an acid gas, by diſtilling the minerals called *fluors* with oil of vitriol, as in the proceſs for obtaining the acid of fluors. (*See Dictionary of Chemiſtry, article Fluors.*) And he has obſerved the following properties of this gas, to which he gives the name of *Fluor acid air.* Exp. and Obſerv. II. 187. and III. 285.

This acid vapour or gas no ſooner came into contact with water than part of it was abſorbed, and at the ſame time the ſurface of the water became covered with a *ſtoney film,* ſimilar to that produced by the

mixture of the acid of fluors with water, and which Mr. *Schecle* pretends to be a *quartz* or *flint*. When this film was broken, another cruft was formed on the furface of the water, and fo on fucceffively till the whole of the gas was abforbed by the water, which thereby becomes impregnated with a very volatile acid. As this acid is fo readily abforbed by water, it requires to be confined in quickfilver.

101. This gas retains its acid properties; for befides its uniting fo readily with water, it forms a cloud with alkaline gas, defcribed in chap. X. and it may be abforbed by chalk, from which it extricates calcareous gas.

102. This gas was *abforbed* by *charcoal*, by *ruft of iron*, and by *alum*, the furface of which it rendered white and opake, by feizing the watery part of the alum. When *falt-petre* was expofed to it, the veffel became filled with red fumes, and the gas was gradually diminifhed till only one tenth part of it remained. One fourth part of this refiduum was abforbed by lime-water, in which it occafioned a precipitation.

103. Water impregnated repeatedly with this acid gas, and freed from the earthy cruft, being heated, was found to yield a gas which did not form any cruft with water, but poffeffed all the properties which have been obferved of vitriolic acid gas.

104. From the above properties of this fluor acid gas, Dr. *Prieftley* is induced to think that the *fluor acid* is *not a particular acid*, but is the *acid of vitriol*, charged with as much phlogifton as is neceffary to give to it the form of gas, and alfo with much of the earthy matter of the fluor. And he is confirmed in this opinion from the following obfervations:

1. That fluors contain phlogifton, appears evident from the effects of diftilling them with nitrous acid;

by

by which means nitrous gas, and a gas capable of producing a precipitation in lime-water, are formed.

2. It appears no leſs evident, that an earthy matter is raiſed along with this gas, from the cruſt which is precipitated from the gas, when water is added.

3. The gas obtained by applying heat to the water impregnated with fluor acid gas, poſſeſſes all the known properties of vitriolic acid gas; the water having deprived the acid of the earthy matter which gave to it the peculiar properties of the fluor acid.

4. When nitrous or marine acids are ſubſtituted inſtead of vitriolic acid, in the proceſs of obtaining the fluor acid, none of the gas that is capable of forming a cruſt with water is produced. *Exp. and Obſerv. vol.* III. *p.* 288.

Mr. *Scheele* however affirms, that the fluor cruſt was produced, by diſtilling fluor with nitrous or marine acids.

Nevertheleſs, Dr. *Prieſtley* has remarked a difference between water impregnated with vitriolic acid gas, and water impregnated with fluor acid gas, namely, that the former is capable of being converted into ice by cold, but that the latter is not. He thinks that this difference may proceed from the earthy or fluor cruſt. *Id. vol.* III. *p.* 360.

M. *Monnet* endeavours to confirm by experiments the opinion of Dr. *Prieſtley*, that the acid obtained by diſtilling a mixture of ſpar and oil of vitriol, is not a peculiar acid, but he thinks that it is the acid of vitriol employed in the proceſs which has been rendered volatile, by combining with the earthy principle of the ſpar. He found, after he had obtained as much acid as he could by diſtillation from that mixture of ſpar and oil of vitriol, that by adding water to the acid reſiduum, he obtained more acid by diſtillation; and that the reſiduum after this

fecond operation was no longer acid. He concludes from this experiment, that the whole of the vitriolic acid is thus volatilized, and that the earth of the fpar is rendered volatile by means of that kind of combination with the vitriolic acid, which is called *with excefs of acid.* He further found, that a faline matter which he obtained by lixiviating the refiduum, and which refembled felenites, but was really different in its properties, being diftilled in the fame manner with vitriolic acid, the fame volatile acid was thereby produced; and that the cruft formed in the water of the receiver during the diftillation of a mixture of vitriolic acid and fpar, when deprived of its excefs of acid by wafhing in water, became exactly fimilar to this matter obtained by lixiviation of the refiduum. From the acid liquor remaining in the retort, diluted with water, a white precipitate was thrown down on addition of fixed alkali, and a yellow precipitate on addition of a folution of mercury in nitrous acid, which yellow precipitate could not be fublimed, and was not therefore corrofive fublimate, according to the idea of the chemift, who has affumed the fictitious name of M. *Boullanger*, and who contends that the acid obtained in the diftillation of fpar with oil of vitriol is the marine. By fufing fpar with fixed alkali, M. *Monnet* could not obtain any neutral falt. *See Rozier's Journal, Auguft* 1777.

The experiments of M. *Monnet* do not however decide the queftion concerning the nature of the fluor acid. The acid which he obtained wanted the moft characteriftic property of the fluor acid, which is the power of corroding glafs. Poffibly there may be a difference among the ftones called *fluors* or *fufible fpars.*

CHAP.

C H A P. X.

Of Alkaline Gas.

105. NOT only the vapour of acids, but alſo that of *volatile alkali*, may be raiſed into a permanent gas by means of heat, as Dr. *Prieſtley* has diſcovered. Thus by applying the flame of a candle to a phial containing volatile ſpirit of ſal ammoniac, he expelled much vapour, which being received into a veſſel filled with quickſilver, continued uncondenſed by cold. When mild volatile alkali was employed, he obſerved that much of the gas which combines with alkaline and calcareous ſubſtances was alſo expelled. He therefore preferred the cauſtic volatile alkali, for the purpoſe of obtaining this alkaline gas. *Exp. and Obſer.* I. 163, *&c.*

106. Alkaline gas is very readily and copiouſly *abſorbed by water*, with which it forms a very ſtrong volatile alkaline ſpirit. It alſo *diſſolves ice* as faſt as if the ice were expoſed to a hot fire. This gas *unites with the marine and vitriolic acid gaſes*, forming concrete ammoniacal ſalts; and with the *gas of calcareous ſubſtances*, with which it concretes into oblong ſlender cryſtals. *Ibid.* Although volatile alkali readily acts upon copper, yet this metal was not affected by alkaline gas. *Id. vol. II.* 232.

107. Alkaline gas, mixed with air, was found to be inflammable. *Ibid. Cygna* ſays alſo, that air ſaturated with volatile alkali is inflammable.

Alkaline gas was encreaſed in its dimenſions by *electric ſparks* paſſing through it; and when as much of the gas, thus treated, was abſorbed by water as could be done, the reſiduum was inflammable. *Exp. and Obſerv. vol.* II. *p.* 240.

108. In the preceding chapters the ſeveral ſpecies of gaſes, hitherto known and diſtinguiſhed from each other, by their peculiar properties, have been deſcribed. But as two or more of theſe ſpecies are frequently obtained from the ſame ſubſtance, and by the ſame proceſs; the following chapters will contain ſome obſervations relative to the kinds and quantities of gas produced from certain ſubſtances, and in the laſt chapter will be added ſome conjectures and ſpeculations concerning the theory of theſe fluids.

CHAP. XI.

On the Gas extricated from putrefying Subſtances.

109. A Permanently elaſtic fluid, or gas, eſcapes from animal and vegetable ſubſtances undergoing the putrefactive fermentation.

This gas conſiſts of two different kinds mixed together. One of theſe renders cauſtic alkalies mild, and precipitates lime-water, as Dr. *Mackbride* has ſhewn. The other kind of gas was obſerved by Mr. *Cavendiſh* to be *inflammable*. *See Chap. IV. on inflammable gaſes.*

In order to aſcertain the quantity and proportion of theſe two gaſes, Dr. *Prieſtley* put a piece of mutton, weighing four pennyweights and ſix grains, into a jar filled with quickſilver, and inverted into quickſilver, and he found that the quantity of gas emitted during the putrefactive proceſs, was, in bulk, equal to $2\frac{1}{4}$ ounces of water, of which quantity $2\frac{15}{100}$ ounce meaſures were of the former kind of gas, and the remainder was inflammable. It is obſervable, that all the inflammable gas was extricated in the beginning of the proceſs. *Exp. and Obſ. vol.* III. 344.

From

From 7640 grains of putrefying broth, (which contained about 163 grains of solid matter) one grain of inflammable gas was procured by Mr. *Cavendish. Phil. Trans.* 1766.

CHAP. XII.

Of the Gas obtained by Fire from Animal and Vegetable Substances.

110. MUCH elastic fluid is produced in the distillation of animal and vegetable substances. Dr. *Hales* has ascertained the quantity of gas which he procured from many of these substances. From his *Analysis of Air*, the following summary of the results of his experiments is collected;

1 cubic inch of *hog's blood*, yielded	33 cubic inches of gas.			
½ cubic inch of *deer's horn* - - -	117	equal to one seventh of its wt.		
½ cubic inch of *oak*	108	—	one third	ditto.
388 grains of *Indian wheat*	270	—	one fourth	ditto.
1 cubic inch of *pease*	396	—	one third	ditto.
437 grains of *mustard seed*	270	—	one sixth	ditto.
142 grains of dry *tobacco*	153	—	one third	ditto.
1 cubic inch of *oil of aniseed*	22			
1 cubic inch of *oil of cloves*	88			
1 cubic inch of *honey* mixed with *calcined bones*	144	—	one ninth	ditto.
1 cubic inch of *bees-wax*	54	—	one tenth	ditto.

1 cubic

1 cubic inch of *coarse sugar*, yielded	126 cubic inches, equal to one tenth of its weight.		
1 cubic inch of *tartar*	504	—	one third ditto.
½ cubic inch of *salt of tartar*	112	--	one ninth ditto.
¼ cubic inch of *human calculus*	516		
½ cubic inch of *stones* taken from a human gall bladder	108		

Van Helmont computes that of 62 pounds of *charcoal* 61 pounds may be reduced into gas by burning. *Complex. atq. mistion. elem. figm.* 13.

It may be remarked generally, that the elastic fluid, produced by fire from animal and vegetable matters, is chiefly a mixture of *calcareous gas*, described in chap. III. and of another gas which is *inflammable*, and which may be separated from the former by exposure to water; by which means the inflammable gas will be left alone, the other being almost totally absorbed by the water. The inflammable gas thus obtained separate from the other, is not quite pure; for I found that a gas obtained by distilling tartar, which did not shew any marks of its containing air when mixed with nitrous gas, being exposed to water and lime-water till no more could be absorbed, left a residuum which was inflammable, and which, on being mixed with nitrous gas, became turbid, and was a little diminished; which shews that the residuum contained a small portion of air, mixed with the inflammable gas.

CHAP.

CHAP. XIII.

Of the Gases in Mines and other subterranean Places.

111. A Noxious gas is found in many caverns, as in the famous *Grotta del Cane*, in mines, wells, and other deep pits. This gas, which by *English* miners is called *Choke-damp*, is heavier than common air, and therefore lies chiefly at the bottom of pits; extinguishes flame; precipitates the lime of lime-water; and is noxious to animals: from these properties, which it possesses in common with the gas obtained from calcareous and alkaline substances, it has been reckoned to be of the same kind, as that which has been described under the name of *calcareous gas*. See Chap. III.*

112. Another kind of gas found in mines and other deep pits, is called *Fire-damp*, from its inflammability. It is lighter than air, floats near the roofs of mines, and is apt to catch fire and explode. This is one of the gases which have been enumerated under the name of *Inflammable gas*. *See Chap. IV*.

* Miners who work in mines that are subject to this damp, generally carry down with them, into their pits, a lighted candle to try the salubrity of the air. They can, however, remain with safety several hours in pits where a candle cannot burn. I have seen them working in the shaft of a coal-pit several yards below the part of the shaft where a candle was extinguished. For, as has been already observed, in treating of calcareous gas, flame may be extinguished by mixing a smaller quantity of noxious gas with air than is sufficient to prevent respiration: but where the damp is so strong, that not only the flame of the candle, but also the redness of the burning wick is extinguished, the miners never venture to remain a minute, knowing that degree of damp to be quickly fatal to animal life.

CHAP. XIV.

Of the Gas of Waters.

113. AN elastic fluid may be expelled from *common water*, by *removing the pressure of the atmosphere*, or by *boiling*. But although the greater part of the air or gas may be expelled by these means from water, yet M. *de Luc* shews, from many laborious experiments, that water obstinately retains a certain quantity of air or gas, which cannot be extricated by boiling, by the air-pump, or by any other known means, than by a long-continued agitation in vacuo; and he further shews, that when water is thus deprived of all the air that can be separated from it, it then becomes capable of sustaining, without boiling, a much greater heat than can be given to it in its common state, even to 240° of *Fahrenheit*'s scale, or more. The elastic fluid contained in water, may be also separated by *freezing*. Accordingly *ice* is always observed to contain many bubbles.

From 54 cubic inches of well-water, Dr. *Hales* obtained one cubic inch of elastic fluid; and from a pint of pump-water Dr. *Priestley* procured one quarter of an ounce measure of a gas, in which a candle could not burn, but a mouse lived. *Exper. and Obs. vol. I.* 160. The water of another pump yielded one fourteenth of its bulk of gas. *Id. vol. II.* 223.

A much larger quantity of gas is contained in many *mineral waters*. Thus from 411 ounces of the water of *Rathbone place*, Mr. *Cavendish* obtained above 75 ounce measures of gas, of which quantity he observes, not above twenty measures were extricated before the water boiled. *Philos. Trans. vol. LVII.*

Some

Some authors talk of a much larger quantity of gas being contained in water. Thus *Mariotte* affirms that a bubble of elaſtic fluid, expelled by heat from water, did occupy, when reduced to the temperature of the atmoſphere, a ſpace, ten times greater than the ſpace occupied by the water which had contained it.

But Dr. *Hales* ſuſpects that part of this gas produced in *Mariotte*'s experiment, (which was made by applying heat to a drop of water included in a glaſs thimble filled with oil and inverted in oil) proceeded from the *oil:* for oil alſo contains a conſiderable quantity of gas, according to Dr. *Hales*'s experiments. *Hales*, *Appendix.*

Other mineral waters yield a very ſmall quantity of gas by being heated. From 54 cubic inches of *Pyrmont* water, Dr. *Hales* procured two cubic inches of gas, which he ſeems to have erroneouſly conſidered as air. *Bath* water yields only one thirtieth of its bulk of gas, according to an experiment of Dr. *Prieſtley*; and of this quantity, one half had the properties of calcareous gas, and the other half of air in which a candle had burnt out. *Exper. and Obſerv. vol. II.* *p.* 223. Dr. *Hales* procured no more gas from two quarts of *Bath* water, than was equal in bulk to half a pea. *Appendix.*

114. Dr. *Hales* juſtly attributed the peculiar briſkneſs and ſparkling quality of *Pyrmont* and other mineral waters to the gas which he found was contained copiouſly in them. *Hoffman* alſo obſerved, that ſome mineral waters in *Germany* contained nothing ſaline, but that they abounded in a volatile principle, to which he gives the name of *ſulphureous aereo-ethereo elaſtic ſpirit.* And Mr. *Venel* ſhewed in 1750, that the waters of *Seltz* were neither acid nor alkaline, but con-

contained one fifth of their bulk of an elaſtic fluid, to which they owed their peculiar properties: and he endeavoured to imitate this mineral water, by adding to a *French* pint of water two gros of mineral alkali, and a ſufficient quantity of marine acid, to ſaturate the alkali. This mixture being made in a ſtrait-necked cloſe veſſel, the gas which was expelled from the alkali by means of the acid was not allowed to eſcape; but it impregnated the water ſo ſtrongly, that this water was found to contain twice as much gas as the native mineral water.

Mr. *Venel* does not however diſtinguiſh the gas contained in mineral waters from air.

Dr. *Seyp* of *Pyrmont* in the year 1736 conſidered this fluid to be the ſame as that which is found in the *Grotta del Cane*, and other ſubterranean places: and Dr. *Brownrigg* ſent to the Royal Society a paper, in which the gas of *Pyrmont* and *Spa* waters is ſaid to be analogous to the choke-damp or permanently elaſtic gas of mines, which is ſhewn in chap. XIII. to be that gas which is in this Treatiſe called *calcareous*. Phil. Tranſ. vol. LV.

Mr. *Cavendiſh* obſerved, that the gas obtained from the waters of *Rathbone-place* occaſioned a precipitation in lime-water; and he is induced to believe, that the greateſt part of it is of the ſame nature as the gas contained in calcareous earths: but he alſo found, that $\frac{875}{7500}$ of the elaſtic fluid contained in this water were air.

115. Mr. *Cavendiſh* diſcovered that calcareous earth is ſuſpended and diſſolved in the waters of many ſprings, by means of their contained gas. By an accurate analyſis of the waters of *Rathbone-place*, he obtained, from 494 ounces of theſe waters, 271 grains of

of earth, which, excepting a few grains of magnesia, was of the calcareous kind. He further shews, as has been already remarked, that the gas obtained from calcareous or alkaline substances is capable of dissolving calcareous earth, that is, of making it soluble in water. It may seem extraordinary that this gas, which is known to precipitate the lime from lime-water, should also render this earth soluble in water; but the fact is uncontrovertible; for besides that this or some very similar gas is proved to be the medium by which the calcareous earth is kept suspended in *Rathbone-place*, and other waters, it is shewn by Mr. *Cavendish*, that if to lime-water, which has been rendered turbid by means of calcareous gas, more of the same gas be added, this water will, by this addition, be enabled to redissolve the precipitated lime, and will be again rendered pellucid. And indeed this phenomenon is analogous to other well-known chemical facts. For many of the precipitates, formed by adding alkalies to the solutions of metals in acids, may be redissolved by a further addition of the alkaline precipitant.

116. Mr. *Lane* has shewn that the gas of mineral waters is capable of *dissolving iron*; and that by means of this fluid, without any other menstruum, the iron is dissolved and suspended in many chalybeate waters. These chalybeate waters deposite their iron when exposed to air; for the gas, by means of which it is suspended, is volatile, and escapes upon exposure to air *. But

* Dr. *Hales* has observed, that when *mineral waters* had been deprived of their elastic fluid, they lost their power of tinging an infusion of galls. (*Appendix.*) And indeed *Van Helmont*, long before, knew that the escape of the spirituous gas, from these waters, by exposure to air, was accompanied with a loss of their aci- dulous

But Dr. *Brownrigg* has obſerved, that the gas does not eſcape from the water which it impregnates, unleſs the water be in contact with air; for when the *Pohun* water was excluded from air, but at the ſame time liberty was given for its gas to riſe into an empty bladder, the gas did not ſeparate from the water by any ſpontaneous motion, but on the contrary, it remained united with the water, when expoſed to the greateſt heats of our climate. When the impregnated water is thus excluded from air, the gas will eſcape but ſlowly with any heat leſs than that of 110° of *Fahrenheit*'s thermometer, although ſuch heat be ſufficient for the diſtillation of water; neither can this gas be wholly expelled by a heat of 160° or 170°, continued two hours. This adheſion ſhews, that the gas exiſts in the mineral water with the other ingredients in a ſtate of ſolution; and in the ſame proportion in which the gas is expelled, in the ſame alſo are the martial and earthy parts ſeparated. *See Dr. Brownrigg's paper on Pohun waters, Phil. Tranſ. vol. LXIV.*

There is reaſon to believe that the gas may be more intimately combined with the ingredients of ſome mineral waters than with thoſe of others, and cannot be ſo eaſily expelled. Dr. *James Keill* obſerved, that a mineral water near *Northampton* loſt its ſpirituous quality, by being long kept included in a *Florence* flaſk hermetically ſealed. The combination of the gas with the water may have been rendered more perfect by time. Perhaps the reaſon why ſo little gas can be extricated from *Bath* water, (ſee §. 113.) may be, that it is more intimately combined with that water,

dulous quality, and a depoſition of the ferruginous matter diſſolved in them. *Paradoxum quartum*, §. 2, 9, 10.

water, or united with other ingredients which retain and fix it more than in the waters of *Pyrmont*, and others which ſparkle much.

117. Gas may be *ſeparated from water*, not only by the means mentioned in §. 113, but alſo by addition of an acid, which occaſions an effervеſcence, and conſequently an eſcape of the gas. Hence the acidulous waters are made to ſparkle, by adding juice of lemons, or *Rheniſh* wine.

118. The diſcovery of gas being the principle to which the briſkneſs and peculiar properties of the mineral waters called acidulous are principally owing, having been aſcertained; and Dr. *Hales* and Mr. *Cavendiſh* having ſhewn, that the gas of calcareous ſubſtances was capable of being abſorbed by water, it occurred to Dr. *Prieſtley*, that the artificial impregnation of water with gas might be applied to uſeful purpoſes, and that mineral waters might be thus imitated. It was obſerved, that the water which had been diſtilled from ſea-water, although free from any ſaline matter, was not ſo palatable or briſk as pump-water. This defect Dr. *Prieſtley* propoſed to ſupply, by impregnating the diſtilled water with the gas extricated from chalk by means of oil of vitriol. And he publiſhed an account of an eaſy method of effecting this impregnation. His method conſiſted in collecting a ſufficient quantity of his gas in a bladder, and in forcing the gas from the bladder through a bent tube into the water intended to be impregnated; which water was contained in a bottle inverted into a baſon filled alſo with water. The gas thus remaining in contact with the ſurface of the water within the inverted bottle, is gradually abſorbed, and the abſorption is haſtened, by agitating the apparatus. The

water, by being impregnated, acquires the taste of the acidulous mineral waters; and accordingly this artificial impregnation of water with gas has been lately much practised, in order to imitate these mineral waters. Dr. *Percival* observed, that the water thus impregnated acquires more of the sparkling quality of *Pyrmont* water, by being kept some time. *Exper. and Observ. vol. I. p.* 32.

This impregnation of water with gas is much facilicated by Dr. *Nooth*'s invention of an elegant and well-contrived apparatus of glass vessels for this purpose, an account of which is published in the *Philos. Trans. vol. LXV. See also Plate, fig.* 4, *and the explanation.*

119. The gas contained in water is said by some authors to be *more expansive* than air is; that is, that by an equal diminution of pressure upon these two elastic fluids, the bulk of the former is much more enlarged than the bulk of the latter. *S'Gravesande* observed, that a bubble of the gas in water expanded so as to occupy a space 15000 times greater; when the common air suffered an expansion of only 300 times. And *Muschenbroek* affirms, that he has seen a particle of this gas expand itself to a size 46,656,000,000 times greater. But, he adds, such particles are not always to be observed in water; and he conjectures that this gas, as well as air, consists of particles of different densities and elasticities. *Introd. ad Philos. Nat.* §. 2051. 2063.

That these singular expansions of bubbles of gas in water appeared as is represented, cannot be doubted, when we consider the accuracy and ability of *s'Gravesande* and *Muschenbroek*. But that the gas of water possesses an elasticity so much greater than air,

air, is an inference not easily to be admitted. And may not this phenomenon be otherwise explained? Water and other liquids are known to retain so powerfully the air or other elastic fluids which happen to be united with them, that these elastic fluids cannot be *immediately* thence expelled, either by boiling or by removing the pressure of the atmosphere; but while the liquids remain freed from this pressure, the air or other elastic fluid separates from them very slowly and gradually, forming a bubble which becomes more and more large, from the gradual accession of exceedingly small and almost invisible particles of such elastic fluid. This very slow separation of air from liquors, and the gradual formation of bubbles, was particularly noticed by M. *de Luc* when he was making thermometers. It seems therefore probable, that the enlargement of the bubbles observed by the *Dutch* philosophers, did not proceed merely from an expansion of a given quantity of air or other elastic fluid, but principally from the accession of more particles of this fluid disengaging themselves from the water during the experiment, and uniting with the bubbles ready formed.

Muschenbroek says also, that by *doubling* the pressure he reduced the elastic vapours of a fermenting paste to a quarter of its former space: and he thinks that most elastic fluids are not subject to the same law as air is, namely, that the spaces occupied by them are inversely as the powers with which they are compressed. *Introd. ad Phil. Nat.* §. 2051.

As *Muschenbroek* does not relate the manner in which the abovementioned experiment was made, we cannot say whether some error might not arise from condensation of watery vapours, or from any absorp-

 tion

tion of gas. A different refult however was the confequence of the following experiment.

I filled a bent tube open at one end only with fome gas obtained by adding vitriolic acid to chalk. By pouring mercury into the tube, a quantity of this gas was included between the clofe end of the tube and the furface of the mercury. I meafured the fpace occupied by the gas thus expofed to the compreffion of the atmofphere, and alfo of the column of mercury in the open leg of the bent tube above the furface of that fluid in its clofed leg. I then varied the height of this column, by pouring more mercury into the tube, and I obferved the refpective diminutions of fpace which the gas fuffered from the encreafed compreffions. By comparing the feveral obfervations which I had made, I found that the fpaces occupied by the gas, under different preffures, were to each other inverfely as their refpective compreffing forces, and confequently that this elaftic fluid is fubject to the fame law, in this refpect, as common air is. *

* The bulk of every permanently elaftic fluid is probably in the inverfe proportion to its preffure, with the fame *heat*. But as concrete bodies are fubject to very different expanfions by equal degrees of heat, fo alfo are gafes. Dr. *Prieftley* has made experiments to meafure the expanfions of feveral of thefe fluids, while the mercury of *Fahrenheit*'s thermometer was expanded 10 degrees. The proportions of thefe expanfions to each other are expreffed in the following table.

Common air	——	1.32	Deflagrating air	—	2.21
Inflammable gas	—	2.05	Phlogifticated air	—	1.65
Nitrous gas	——	2.02	Vitriolic acid gas	-	2.37
Calcareous gas	—	2.20	Alkaline gas †	—	4.75
Marine acid gas	—	1.33			

† Dr. *Prieftley* expreffes fome doubt of the accuracy of his experiments concerning alkaline gas. *Vol. III.* 347.

CHAP.

CHAP. XV.

On Fulminating Gases.

120. SOME gases are *so suddenly* extricated or formed from the substances containing them, by the heat applied, or by means of the action of the parts of these substances on each other, or by the concurrence of both these causes, that in the instant of their formation an *explosion* or *fulmination happens.*

121. A gas of this kind is produced by the *deflagration of nitre* with inflammable substances. Hence the explosion of *gun-powder*, and of the *fulminating powder* composed of nitre, salt of tartar, and flowers of sulphur.

The quantity of gas obtained from gun-powder was found by the experiments of Mr. *Robins** to be equal in bulk to 244 times the bulk of the exploded gun-powder, when this gas is compressed by the atmosphere and reduced to the same heat: and as the expansion of the air appeared, from his experiments, to be encreased four times by the heat of iron just beginning to be white, he infers, that if the elastic fluid of gun-powder be equally affected by heat as air is, its expansive force, in the instant of explosion, is nearly a thousand times greater than the pressure of the atmosphere; a force sufficient to produce the effects of gun-powder.

Boyle observed that the gas of gun-powder was *noxious* to animals; and Dr. *Priestley* found, that the gas obtained by applying heat to a mixture of nitre and sulphur was the *nitrous gas.* Exper. and Observat. vol. II. p. 90.

* On Principles of Gunnery.

122. Some *metallic precipitates* are capable of fulminating. The preparation called *fulminating gold* is well known. The gas produced during its explosion has not been examined.

Mr. *Bayen* has discovered that various *mercurial precipitates* fulminate, when they are triturated with about one sixth part of flowers of sulphur, and afterwards heated. Of these precipitates the following are the principal.

a. Precipitates made by adding a *fixed alkali, mild* or *caustic*, or a *volatile mild alkali*, or *lime-water*, to a solution of *mercury* in *nitrous acid.*

b. Precipitates made by adding *fixed alkalies mild* or *caustic*, or *lime-water*, to a solution of *corrosive sublimate* in water.

c. A precipitate or *mercurial calx* prepared by digesting, in a sand-bath, *turbith mineral*, with a solution of *fixed alkali* in water, till the precipitate became red.

Mr. *Bayen* remarks, that no detonation was produced by mixing these precipitates with powdered charcoal, and applying heat to the mixture; and also, that the detonation, by means of sulphur, was observed to be so much the stronger, as the precipitates were more deprived of their acid. Thus the precipitate from the solution of mercury in nitrous acid, by means of volatile alkali, detonated very weakly, till it had been previously deprived of much of its adhering acid by calcination: and no detonation was produced by the precipitate which had been made by adding volatile alkali to a solution of corrosive sublimate in water; for it appeared, upon exposing this precipitate to a subliming heat, that the whole of it was in the state of sweet mercury, and that consequently much acid adhered to it.

123. The

123. The detonation of nitrous and other fulminating powders, is an effect too ſtriking not to have engaged the attention of philoſophers. *Stahl* maintains that the water of the nitre is converted into air. Mr. *Macquer* very ingeniouſly conjectures that, in the operation, a *nitrous ſulphur* is formed, which inflames at the inſtant of its formation. *See the article, Detonation of Nitre, of the Dictionary of Chemiſtry.*

Dr. *Black* is of opinion, that the fulminating gold derives its detonating property from ſome gas which adheres to it, and which it had received from the alkaline precipitant uſed in the operation. However this explanation may be applicable to the fulminating gold, it cannot be applied to explain the fulmination of the *mercurial precipitates* of Mr. *Bayen*; for ſome of theſe were precipitated by cauſtic alkalies, and by lime-water. Mr. *Bayen* thinks that the fulmination of theſe precipitates is the conſequence of a commotion excited between the mercury and the ſulphur at the inſtant of the combination taking place, by which cinnabar is formed. And this opinion is confirmed by the heat, and even ſpontaneous inflammation which happens when ſulphur and crude mercury combine together.

Whatever be the cauſe which excites ſuch commotions, the *detonation* itſelf conſiſts in the ſudden concuſſion which the air receives from the inſtantaneous production of an elaſtic fluid expanding itſelf with great violence. In the notes to the firſt *Engliſh* edition of the Dictionary of Chemiſtry I ſuggeſted, at the article *Fixable Air*, that the elaſtic fluid produced in the detonation of nitre was formed from the *nitrous acid* probably combined with the *inflammable principle*, and that theſe are *converted into the ſtate of gas* by the violence of the action of this acid and of the inflammable matter

on each other. This opinion of the *conversion of nitrous acid into gas*, by the *detonation of nitre*, has been since confirmed and established by late experiments, which shew first, that the gas thereby produced is principally that which we have described under the name of *nitrous gas*; and secondly, that this nitrous gas is the nitrous acid in the state of *gas*, probably combined with inflammable matter, and is again convertible into the liquid nitrous acid, by being mixed with air.

The detonation likewise of Mr. *Bayen*'s mercurial precipitates is occasioned by the production of an elastic fluid; and I think that this fluid also proceeds from the conversion of some adhering portion of the acid, in which the mercury had been dissolved, into the state of gas, (together probably with some of the phlogiston of the metal or sulphur) by means of the violent heat and motion excited between the mercury and the sulphur in the act of combination, while the mercury is forced from its union with the adhering acid. For it appears, both from Mr. *Bayen*'s experiments, and from the analogy of other precipitations, that some acid always adheres to the precipitate; and probably also some of the alkaline or earthy precipitant. It is true indeed, that when *much* acid adheres, the fulmination does not happen, as Mr. *Bayen* remarks. The reason of which may be, that the combination between the mercury and sulphur is by this abundant acid so prevented or retarded, that the heat and motion requisite to effect the conversion of acid into gas are not produced.

It appears further, from Mr. *Bayen*'s experiments, that not only the nitrous acid but also the *marine acid* is *capable of detonation*, and, according to the above conjectures, of being *converted into gas*.

CHAP.

CHAP. XVI.

Conjectures and Speculations concerning the Theory of Gases.

124. WE daily see the same bodies assume very different appearances or states, under different circumstances; and of such changes, no instances can be adduced more curious and surprizing than those which we have described concerning the formation of the various kinds of permanently elastic fluids. We have seen that solid, hard, and dense bodies lose at once their cohesion, acquire a repelling force, and suddenly expand into a space many hundred or thousand times greater than that which they before occupied; forming rare, invisible, elastic fluids. We have also seen that the most expansive fluids can be again restored to a concrete state, and may conduce to the formation of very hard and solid bodies.

To explain these changes, exceeds, I fear, the limits of our present physical knowledge. Conjectures however may be admitted; which, as they are not intended to decide, do not establish or confirm errors, but may be useful, by suggesting certain questions to be ascertained by future experiments. With this view then only we proceed to the following speculations.

125. Many well known facts shew, that matter is endowed with two contrary qualities, an *attractive* and a *repulsive power*, of which sometimes one, and sometimes the other exerts itself in different circumstances. Natural philosophers have observed, that the particles of bodies attract each other within certain distances; and that, when they are placed beyond the sphere of each other's attraction, they begin to exert a repulsive power. In order therefore to change a cohering

hering concrete body into a repelling fluid or gas, is it not ſufficient that the particles of that body be removed to a diſtance from each other, greater than the ſphere of their attraction, that their repulſive force may begin to act †?

May not *heat*, which is known to expand all bodies, remove their particles to ſuch diſtances from each other, that their attraction ſhall ceaſe, and their repulſion commence? And is not this the mode of action by which heat raiſes water, mercury, and other volatile bodies, into elaſtic vapours; ſome of which by cold are again brought within the ſphere of each other's attraction, and are condenſed; while others, poſſeſſed of a ſtronger repulſive power, remain in an expanded ſtate, forming ſome of the permanent-elaſtic fluids, called *gaſes*.

126. May not alſo a *violent motion* or *quick vibration*, excited among the minute particles of bodies, occaſion

† Thus *Sir Iſaac Newton* ſays, (*Optics*, *Quer.* 31.) "As in "algebra, where affirmative quantities vaniſh and ceaſe, there "negative ones begin; ſo in mechanics, where *attraction* ceaſes, "there a *repulſive* virtue ought to ſucceed. And that there is ſuch "a virtue, ſeems to follow from the reflections and inflections of the "rays of light. For the rays are expelled by bodies in both "theſe caſes, without the immediate contact of the reflecting or "ineffecting body. It ſeems alſo to follow from the emiſſion of "light; the ray ſo ſoon as it is ſhaken off from a ſhining body by "the vibrating motion of the parts of the body, and gets beyond "the reach of attraction, being driven away with exceeding great "velocity. For that force, which is ſufficient to turn it back in "reflection, may be ſufficient to emit it. It ſeems alſo to follow from "the production of air and vapour. The particles when they are "ſhaken off from bodies by heat, or fermentation, ſo ſoon as they "are beyond the reach of the attraction of the body, receding "from it, and alſo from one another with great ſtrength, and "keeping at a diſtance, ſo as ſometimes to take up above a mil- "lion of times more ſpace than they did before in the form of a "denſe body."

ſion a ſimilar ſeparation of theſe particles, and a conſequent change from a concrete to a repelling ſtate? Thus the particles of fire and light are ſuppoſed by *Sir Iſaac Newton* to be thrown off from ignited or luminous bodies, by the motion and vibration of their parts. May not alſo the violent inteſtine motion excited in the particles of bodies, during their *decompoſition* and *ſolution by menſtruums*, as of *metals by acids*; and alſo of bodies undergoing the *vinous, putrefactive*, or *other fermentations*, produce in the ſame manner the gaſes which are known to be formed in theſe ſeveral operations? For when any two united particles are torn aſunder, by the ſuperior attraction or affinity of a menſtruum, or ſolvent, muſt they not, at the inſtant of ſeparation, recede from each other with a force equal to that with which their disjunction was reſiſted; in the ſame manner, as the two parts of a cord, ſtretched till it breaks, recoil towards the oppoſite points of tenſion? And the effects of the violent ſeparations of the particles of bodies, which occur in chemical decompoſitions, ſolutions, and fermentations, will appear very great, when we conſider the *minuteneſs* of the particles engaged in theſe operations, and how much the activity, or force of the attraction and repulſion of bodies, depends on the minuteneſs of their ſize. For it is known, that the attraction of any two bodies to each other, encreaſes as the diſtance between them decreaſes, in ſome high ratio; and as the diſtance at which all the particles of any body can exert their attractive power upon any other contiguous body, may be ſuppoſed equal to the ſemi-diameter of the attracting body; therefore the particles of large bodies muſt exert that power at a greater diſtance than thoſe of ſmaller bodies, and conſequently the attractive

tive force of large bodies must be less than that of smaller bodies, relatively to the quantity of matter contained in each.

127. Some bodies are more disposed than others to be changed from a concrete to an elastic state. Those which cohere with least force, will most easily have their particles thrown out of the sphere of each other's attraction. And this seems to be the case with all those bodies which are called *volatile*, as water, spirit of wine, and ether. And is not even the *evaporation* of cold water, and of some other volatile liquids, especially in vacuo, occasioned by some of the particles, at the surfaces of these liquids, where they are not compressed by other particles, being thrown by the agitation, which generally prevails in fluid bodies, to such distances, that their repulsive force can begin to exert itself*?

Those bodies which are easily expanded to an elastic state, are also easily reducible to their former state, and are generally condensable by cold into bodies of the same species, as they were of before their volatilization. For, as their cohesive power is weak, so also is their repulsive power; and therefore cold, which approximates the particles of bodies, is capable of bringing them again within the sphere of each other's attraction.

But bodies, on the other hand, whose parts cohere strongly, and which, therefore, cannot be disjoined without violent efforts, such as those which produce the solution and decomposition of bodies, whether by heat,

* Some philosophers have attributed the rise of exhalations and of vapours to the dissolving power of air, exerted upon the moisture on the surface of the earth. But although this cause may concur, it does not solely or principally produce this effect; for water is known to evaporate not only in air, but also in vacuo.

heat, by acid menſtruums, or by fermentations, form elaſtic fluids, whoſe repulſive power is ſtronger, and which cannot be condenſed merely by cold. The violence of the effort employed in theſe operations, appears from the heat with which they are accompanied. From ſuch bodies, therefore, are chiefly formed the uncondenſable fluids, called *Gaſes* †.

128. Of all the concrete bodies which we know, none poſſeſſes ſo ſtrong and general an attractive power as *acids* do; for they are known to unite and combine with water, oils, earths, and metals. Nor do perhaps any bodies reſiſt their action, excepting thoſe compounds which are already ſaturated with acid, as ſulphur is. When we conſider the great activity of acids, and alſo how much the activity of bodies depends on the minuteneſs of their particles, does it not ſeem probable, that the particles of acids are very minute, and that to this minuteneſs of ſize, theſe bodies owe their ſtrong attractive diſſolving power?

129. There is another body which never appears to us in a concrete ſtate, unleſs when combined with other ſubſtances, but which ſeems ſtrongly diſpoſed to unite with every other claſs of bodies, excepting, perhaps,

† "The particles of fluids which do not cohere too ſtrongly, "and are of ſuch a ſmallneſs as renders them moſt ſuſceptible of "theſe agitations which keep liquors in a fluor, are moſt eaſily ſeparated and rarefied into vapour, and in the language of chemiſts "are volatile, rarefying with an eaſy heat, and condenſing with "cold. But thoſe which are groſſer, and ſo leſs ſuſceptible of agi- "tation, or cohere by a ſtronger attraction, are not ſeparated "without a ſtronger heat, or perhaps not without fermentation. "And theſe laſt are the bodies which the chemiſts call fixed, and "being rarefied by fermentation, become true permanent air. "Thoſe particles receding from one another with the greateſt force, "and being moſt difficultly brought together, which upon contact "cohere moſt ſtrongly." *Newton's Optics, Quer.* 31.

perhaps, water, with which it does not ſeem to be capable of combining, but by the intervention of acids. This is the *matter of light*; thoſe minute particles which have been repelled from the ſurface of the ſun, and other ignited bodies; and are abſorbed and combined with acids, and earths, forming the various combuſtible matters, vegetable, animal, and mineral *.

Theſe matters it endows with the property of inflammability, and hence it is called by chemiſts, *Phlogiſton*.

Now the amazing tenuity of the matter of light is well known; and from this property perhaps ariſes its extreme ſuſceptibility of that motion on which heat depends, and the violence with which it combines with thoſe ſubſtances which it moſt ſtrongly attracts. From this ſuſceptibility of motion, muſt not the particles of the matter of light be peculiarly diſpoſed to be agitated and thrown from the ſphere of each other's attraction, and to exert the repulſive faculty? Accordingly, not only light itſelf poſſeſſes eminently this repulſive faculty, but alſo the ſubſtances with which this matter is combined are thereby rendered more volatile, as numberleſs chemical facts demonſtrate.

As therefore the matter of light is ſtrongly diſpoſed to become volatile, and to exert its repellent force; and as it imparts more or leſs of this property to the various ſubſtances with which it is capable of combining, it ſeems particularly adapted to form elaſtic

fluids.

* "Are not *groſs bodies* and *light* convertible into one another, "and may not bodies receive much of their activity from the particles of light which enter their compoſition?" *Newton's Optics*, *Quer*. 30.

fluids: Accordingly, it may be doubted whether, in each of the above-described gafes, fome portion of phlogifton does not enter. But fcarcely any fubftance is fo much difpofed to unite with phlogifton as acids are; and as thefe are endowed with fo ftrong an attractive power, they are probably poffeffed of an equally ftrong repellent power, when they happen to be thrown into an elaftic ftate, and confequently are very capable of being converted together with phlogifton into permanent gafes. Accordingly we fhall find, upon examination of the preceding hiftory of thefe fluids, that in the formation of moft of them, an acid and phlogifton enter into the compofition of the fubftances employed.

Phlogifton is alfo much difpofed to unite with alkaline and other earths, efpecially thofe that are metallic. And accordingly, among the fluids above defcribed, a few will be found which feem to confift principally, if not folely, of phlogifton and fome portion of earth.

As water is powerfully attracted by acids, and is itfelf difpofed to affume an elaftic ftate, (though not permanent) it may alfo enter into the compofition of thefe fluids, and thus acquire, by means of the other component parts, a permanent elafticity.

130. From thefe fubftances, then, phlogifton, and acids, together with fome portion of earth or of water, may not the feveral gafes defcribed in the preceding pages be compounded? To enable us to refolve this queftion, let us take a furvey of thefe fluids: but it may be proper previoufly to obviate an objection which will readily occur, viz. that fo many fluids, fo different in their properties, fhould confift of fo few and the fame elements.

First,

First, it may be remarked, that a great variety of compounds might arise from the difference of the kinds of acids and of earths employed in the processes for producing gases. Thus by the same process, by varying the acid, may be produced, marine acid gas, vitriolic acid gas, or nitrous acid gas.

Secondly, this variety may, and does principally proceed from the diversity in the *mode of combination.* For if any two bodies, A and B, are capable of uniting and combining together chemically, there are two modes in which they can combine; the one in which A predominates, and the other in which B predominates. Thus air unites with, and dissolves a certain portion of water, *(see* §. 8.) and thus a compound is formed, in which air predominates. But water is also known to dissolve a certain portion of air, *(see* §. 9.) and a compound is thus formed, in which water predominates. Thus also ether dissolves a certain determinate proportion of water, forming a compound in which the ether predominates; and water dissolves a certain determinate proportion of ether, forming a compound in which the water predominates. Accordingly, if more water be added to any quantity of ether, than this quantity of ether can dissolve, (but not so much as to be able to form the whole ether into the compound in which water predominates) two distinct compounds will be formed, one floating upon the other, in one of which the ether predominates, and in the other the water predominates; and there will not be besides any other compound or mixture consisting of other proportions of these liquids. Thus too quicklime and water combine in two different modes, forming *slaked lime*, and *lime-water*; in the former of which the lime, and in the latter the water, predo-

predominates. All saline substances unite with water, either in a solid crystallized state, or in the state of a solution; in the former case, the saline substance, and in the latter, the water, being predominant. The two modes in which vitriolic acid and mercury combine, appear in the *vitriol of mercury* and in *turbith mineral*; in the former of which compounds the acid, and in the latter, the mercury predominates. The double mode of combination frequently appears in metallic allays, in which, although the component parts are diffused through each other in different proportions by violent heat, yet, when they are kept long in fusion with the least requisite heat, the precipitations and separations which take place, indicate the disposition to form differently proportioned compounds. Many more instances might be adduced to shew the different modes in which bodies that have a chemical affinity to each other are capable of combining: and indeed so many instances occur, that I am inclined to believe that it may be considered as a general rule, and a rule of the first importance, in the explanation of chemical phenomena.

When a greater number of elements or component parts than two unite together in the formation of a compound, they are capable of more modes of combination. Thus the number of modes in which three bodies may be combined is six, if every combination that is arithmetically possible could be formed into a chemical compound. Four elements might be combined in 24 different modes; five elements in 120 different modes, and so on. Now although our experience does not lead us to believe that every combination among three or more bodies, chemically related to each other, which is arithmetically possible,

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can actually take place in the forming of compounds; yet, from the analogy of the two modes of combination which two elements, thus chemically related to each other, are capable of, as we have above explained, and also from the instances that are known of the various modes of combination, in which three or more elements are formed into different compounds, we cannot doubt that the number of modes does frequently encrease with the number of component parts, although not in the full arithmetical extent.

How much the properties of compounds, consisting of the same component parts, are affected by the different modes of combination, that is, how different they are, is too obvious to require any proof or illustration.

131. We now proceed to examine the constitution of the several permanently elastic fluids described in the preceding chapters, all which may be comprehended under the following seven classes.

1. *Acid gases.*
2. *Alkaline gas.*
3. *Inflammable gases.*
4. *Calcareous gas.*
5. *Nitrous gas.*
6. *Air.*
7. *Phlogisticated air.*

Of Acid Gases.

132. We have seen that the vitriolic, nitrous and marine acids may, when united with any inflammable matter, be converted by heat into those gases which we have called *acid*, because they seem to retain their acid properties, of acting upon the metallic, alkaline, and other substances, with which they combine when in a liquid state; and also, of uniting readily with water, by which they are reduced to their original state of liquid acid. As these fluids are not condensable by the cold of the atmosphere, they have been considered as gases; but from their easy reduction to their former concrete state, and from their retaining

ing their acid properties while in their expanded ſtate, they ſeem to be of the more imperfect kind of thoſe fluids. It may be obſerved, that theſe gaſes are not formed by any violent action, inteſtine motion, or decompoſition of bodies; but that they are raiſed merely, as vapours are, by moderate heat. Do not then theſe gaſes conſiſt of acids volatilized by means of water and phlogiſton? Does not the acid part greatly predominate over the phlogiſtic in their compoſition; and is not the phlogiſton in a very imperfect ſtate of combination with the acid, becauſe this acid is united with much water, and becauſe water does not eaſily combine with phlogiſton? And do not the acid properties of theſe gaſes depend on this imperfect combination with phlogiſton, and on the predominancy of acid in their compoſition*?

Of Alkaline Gas.

133. The elaſtic vapour raiſed by heat from *volatile alkali* was found to be not condenſable by the cold of the atmoſphere; and it has been deſcribed, as the abovementioned acid vapours have, under the name of *gas*. But it may be obſerved of both acid and alkaline vapours, that if upon further examination they be found not condenſable by any cold which we can apply to them, and be therefore properly compre-

 hended

* That the vitriolic acid gas contains the ſame elements as ſulphur does, appears from a fine experiment of Dr. *Prieſtley*, an account of which will probably be given in his fourth volume of Experiments and Obſervations, now preparing for the preſs, but which he has been pleaſed to allow me to mention here. He expoſed ſome water impregnated with vitriolic acid gas to a long-continued heat in a glaſs tube hermetically ſealed: after which, he obſerved that the inſide of the upper part of the tube was coated with white cryſtallizations, that were found upon examination to be perfect *ſulphur*. In this experiment the adheſion of the principles of the gas ſeems to have been ſo weakened by the water, that a part of them ſeparated and formed this new compound.

hended under the definition of *gas* given in chap. I. they must be allowed to be of the most imperfect kind of permanently elastic fluids. For neither the acid nor alkaline elastic fluids can be considered as compounds formed, during their expansion into an elastic state, from decomposed and violently separated parts; but as merely the disjoined parts of the bodies, from which they are raised, retaining, while in their elastic state, the properties of these bodies; and capable of being reduced, when condensed by water, into concretes, or bodies similar to those from which they were formed.

Of Inflammable Gases.

134. We have seen that *inflammable gases* are formed from the vitriolic or marine acids acting on iron, zinc, or tin; from marine acid gas acting upon these metals, or upon almost any inflammable substance; from many inflammable compounds, by means of heat, as from coals, vegetable and animal substances, during the decomposition of these compounds; and from animal or vegetable matters undergoing the putrefactive fermentation.

In the abovementioned different kinds of inflammable gas, we may perceive that acids and inflammable matter are the principal ingredients, not only in the metallic solutions, in which the acid unites with the phlogiston of the metals, but also in the vegetable and animal matters, by the analysis, or by the putrefaction of which, inflammable gases are produced. For in these matters, the vegetable and animal acids abound; and from their inflammability, it appears that the acids are combined with phlogiston. The conversion of the marine acid gas into inflammable gas, by the action of that acid fluid on phlogistic substances, sufficiently shews that an acid enters into the

the compoſition of this inflammable gas. The inflammability alſo of the diſengaged gas of hepar of ſulphur can ſcarcely be ſuppoſed to ariſe from any other matter than phlogiſton and acid.

Other kinds of inflammable gas have been deſcribed, in the production of which no acid is employed; ſuch are the gaſes formed from metals merely by heat, or, by means of alkalies. Theſe inflammable gaſes ſeem to conſiſt of the ſame component parts as the metals themſelves, that is, of phlogiſton and earth in different proportions. In metals the earth predominates, but in this inflammable gas, the phlogiſton predominates. And that the phlogiſton in theſe inflammable gaſes is not pure and uncombined, may be inferred from its not being ſeized upon by the air as ſoon as they come into contact with this fluid; whereas heat, and even ignition, is neceſſary for the decompoſition of theſe, as of other inflammable compounds. Are not all the inflammable bodies that we know, whether in a concrete or expanded ſtate, compounds of phlogiſton, united either with acids, or with earths; with this difference only, that the inflammable concretes, ſuch as ſulphur, oils, bitumens, and metals, are compounds in which the acid or earth predominates over the phlogiſton, and the inflammable gaſes are compounds in which the phlogiſton predominates over the acid or earth.

We have remarked, (§. 127.) that the moſt perfect gaſes are formed by a violent ſeparation of parts. Now, in all the modes of forming inflammable gas, the ſubſtances are diſſolved or decompoſed, and their parts violently torn aſunder. The inflammability alſo of this gas is greater, when the heat is ſuddenly applied, or when the ſolution proceeds with violence.

And accordingly, the properties of this gas indicate it to be of the moſt perfect kind; for, it is the rareſt, and the moſt immiſcible with water, of any known gaſes. Theſe properties probably proceed from the phlogiſton which ſeems to abound in this gas.

Iron, zinc, and tin, are the metals from which inflammable gaſes are moſt eaſily produced: and the reaſon ſeems to be, that theſe metals, when diſſolved by acids, do moſt eaſily part with their phlogiſton, as chemiſts have often obſerved.

Of Nitrous Gas.

135. We have ſeen that inflammable gaſes have been formed by means of the vitriolic, the marine, the vegetable, and the animal acids. But no method has been yet diſcovered of making a perfect inflammable gas, by means of the nitrous acid; although we have ſeen ſome approaches towards it, §. 86.* Nevertheleſs, the *nitrous gas*, deſcribed in chap. V. ſeems to be ſomewhat analogous in its compoſition to inflammable gas. For it is formed from an acid acting upon metallic and phlogiſtic ſubſtances; and the combination of phlogiſton with the acid ſeems to be ſo intimate, that it ſuppreſſes the peculiar qualities of the

* Since the above was ſent to the preſs, Dr. *Prieſtley* has been ſo obliging as to communicate a very curious experiment which he has lately made. He put a pot containing a mixture of iron-filings and ſulphur into a jar filled with nitrous gas, and he obſerved, that after the gas had ſuffered the great diminution mentioned in §. 86. it encreaſed in bulk, and became *ſtrong inflammable gas*. It retained its properties of nitrous gas till it was diminiſhed to leſs than one third. Then it admitted a candle to burn in it with an enlarged flame; after which, it acquired the properties of *phlogiſticated air*, and laſtly it became, as we have ſaid, ſtrongly *inflammable*. Do not this, and the many other extraordinary inſtances of converſion of one gas into others, ſhew that they contain the ſame component parts differently proportioned and combined?

the acid; for this gas does not act as an acid upon metals or other substances; neither does it very readily mix with water, without the contact of air; and even when absorbed by water, it does not communicate its acid qualities to the liquid, till the water has been exposed to air, which decomposes the gas, and disengages its acid, as Mr. *Bewley* has well observed. The phlogiston however, in this gas, does not seem to be so perfectly combined, as it is in the inflammable gases, for the following reasons: 1. This gas is considerably denser, being as heavy as common air is*; whereas inflammable gas is greatly lighter. 2. It mixes more readily with water than inflammable gas does. 3. It parts with its phlogiston more easily; for, no sooner does air come in contact with this nitrous gas, than the phlogiston seems to pass from the latter to the former; and the acid thus deprived of the substance to which it owed its elastic state, is changed into a liquid concrete, or spirit of nitre. Although therefore nitrous gas cannot be inflamed, it appears to undergo a process similar to that of inflammation, namely, a separation of its phlogiston by means of air: and the difference seems to be, that the phlogiston is so firmly combined in the inflammable gases, that it cannot be separated from its acid by the superior attraction of the acid of the air, till its activity has been encreased by ignition; whereas, it is so much less perfectly combined with the acid in the nitrous gas, that it is separated immediately upon mixture with air.

From these reasons, I am inclined to think that a portion of water enters into the composition of this gas, and prevents such an intimacy of combination of

* Experiments and Observations, vol. I. p. 119.

the acid with the phlogiston, as takes place in inflammable gases. And that water enters into the composition of this gas, is further rendered probable, from the copious production of nitrous gas, when the nitrous acid vapour acts upon water. *See Chap. VIII.* §. 99.

If this conjecture be just, the nitrous gas seems to be in an intermediate state between the acid and the inflammable gases.

Of Calcareous Gas.

136. All those gases which occasion a *precipitation in lime-water*, have been generally comprehended under one class, and distinguished by the name of *Fixed Air*. We have seen that they are produced from many different materials: 1. From calcareous, and from alkaline substances, by acids, or by fire: 2. From the combustion of any animal or vegetable matters, or from their decomposition by heat, or by concentrated acids: 3. From animal and vegetable matters undergoing the vinous and other fermentations: 4. From metallic calxes by reduction, and sometimes merely by heat, as from minium: 5. From some metallic and other salts, as green vitriol, by fire: 6. From air decomposed by electricity: 7. From the deflagration of nitre, and in the various processes in which the nitrous acid is used to produce gases: 8. From subterranean pits and caverns: 9. From mineral waters; and probably, they may be obtained from many other substances.

Perhaps, in all these gases, the same mode of combination prevails, although the acids which enter into their composition be different. From the above enumeration of the various modes of production, almost any acid seems capable of assuming this state. But the animal and vegetable acids ap-

pear

pear to be peculiarly disposed to form this gas. For, we find from the experiments of Dr. *Hales*, that a very large proportion of the vegetable essential salts, as tartar, were converted into a gas of this kind; when these saline substances were decomposed by fire. In this operation, the acid disappears, and a gas is produced. For no gas exists in the tartar, or other vegetable body, till it be decomposed; the gas being a peculiar compound formed, during the decomposition of the vegetable matters, by fire, or by fermentation. Thus when tartar is united with fixed alkali, as in making *Rochelle* salt, the alkali, if caustic, is not rendered mild; and, on the contrary, if mild, its gas will be expelled by the tartar, as it would by any other acid: But, if this compound of tartar and caustic alkali, in which no gas exists, be burnt, the alkali remaining will be mild and effervescent; for the acid of the tartar being decomposed by the fire, and formed into a gas, a part of it will unite with the alkaline residuum. And if *soap*, which consists of caustic alkali and oil, be burnt, the alkali will be rendered mild, by the gas formed from the acid, which is known to be a constituent part of oil. Also, if nitre be deflagrated with any animal or vegetable matter, the alkaline basis of the nitre, which is not united with gas while combined with the nitrous acid, will, after the deflagration, be found to be united with gas; that is, rendered mild; whereas, if nitre be deflagrated with zinc or tin, which metals contain no acid capable of conversion into gas, the alkaline residuum will be caustic †.

The

† The production of a mild alkali by deflagration of nitre with charcoal, and of a caustic alkali by deflagration of nitre with filings of zinc, or of iron, has been also noticed by Mr. *Bewly*. *Appendix to Dr. Priestley's third vol. of Exper. and Observ. p.* 387.

The exiſtence of an acid, as a principal conſtituent, and even as the predominant part of this gas, is indicated by ſeveral of its properties. For it acts upon, and diſſolves ſeveral earthy and metallic ſubſtances; it unites with alkalies and calcareous earths, and it effects their cryſtallization, as other acids do; it may be diſengaged from theſe alkaline ſubſtances by ſtronger acids; it has been found to change the blue colour of the juices of turnſole, of litmus, and of cyanus, to red *; and it gives an acid taſte to the water which it impregnates.

The acid quality, however, of this gas, is very weak, being probably counteracted by the other principles, as earth, or phlogiſton, which in many inſtances are known to leſſen or deſtroy the activity of acids †.

Of Air.

137. Of all the gaſes, *air* being of the greateſt importance to us, has been moſt attentively examined by philoſophers; a knowledge, however, of its conſtitution, and of the mode of operation, by which its ſingular effects are produced, has nevertheleſs eluded their inquiries. The exiſtence of an acid, and even of the nitrous acid in air, has indeed been ſuſpected, chiefly, from the neceſſity of air towards the formation of nitre, and

* Dr. *Prieſtley's* Exper. and Obſ. vol. I. 31. and Appendix to vol. II. by Mr. *Bewley*.

† Signor *Fontana*, in a treatiſe entitled, *Ricerche Fiſiche ſopra l'Aria fiſſa*, attributes the acidity of the gas extracted from calcareous ſubſtances by means of oil of vitriol, to the acid employed, which he thinks may be diſſolved in this gas, as water is diſſolved in air, ſo intimately, that neither water nor alkali can ſeparate this acid; and he thinks, that to this volatilized and combined vitriolic acid, the fixed air owes its medicinal qualities, the acid being thus rendered more efficacious than in its proper uncombined ſtate. And alſo Signor *Landriani*, in his *Ricerche Fiſiche intorno allo ſalabrita* dell'

and from the analogous effects of nitre, and of air, in promoting inflammation. But, no experiments have been ever adduced to give such solidity to this conjecture, as those of Dr. *Priestley*, which shew that a fluid resembling air in all its known properties, and even possessing the peculiar properties of air in a much more eminent degree than the atmospherical air itself does, may be produced from nitrous acid mixed with almost any unphlogisticated earth.

Neverthelefs we cannot, with certainty, infer, that the nitrous is the sole acid capable of forming fluids possessed of the properties of air, and consequently that the atmospherical fluid does certainly contain in its composition some of that acid. For a very strong resemblance, between two compounds, may arise from the similarity of the combination, although a component part of one compound may be of a different species from the analogous component part in the other compound. Thus we have seen, that inflammable gases similar in their properties, so far as we have examined them, are formed from very different acids, the vitriolic, marine, and others; and we have also seen, that those gases, which, from their similarity of properties, have been considered as being of the

dell' Aria, maintains, that the acidity of this gas proceeds from the acid employed in the operation of extricating it, and that when this gas is mixed with vapour or volatile alkali, an ammoniacal salt will be formed, which will be found to be a vitriolic ammoniac, if the acid employed had been the vitriolic, and a deflagrating nitrous ammoniac, if nitrous acid had been employed. Mr. *Bewley*, in the Appendix to Dr. *Priestley*'s second volume of Experiments and Observations, very well defends the opinion of the intrinsic acidity of this gas, and shews that the same indications of acidity are exhibited by gases extricated from volatile alkali and from magnesia, by heat, and without intervention of any foreign acid.

the same kind, and comprehended under the same name, *fixed air*, or *calcareous gas*, are similar compounds, formed from very different substances, and probably containing in their composition very different acids. These considerations prevented me, in the first Edition of this Treatise, from admitting the certainty of the nitrous acid being a necessary constituent part of the atmospherical fluid, although it was allowed that the production of one species of factitious air, by means of that acid, with various unphlogisticated earths, was completely ascertained by Dr. *Priestley*'s experiments. The recent experiments that have been since made, and related in §. 31. shew that a pure air may be obtained by means also of the *vitriolic acid*, and seem to leave no doubt, that fluids, possessing all the known properties of the atmospherical fluid, may be produced from more than one acid, and from various kinds of earths*.

Whether the earths employed in the processes for making factitious airs enter into the composition of air, and in what proportion, are questions which cannot be ascertained by the experiments hitherto made †.

If

* An experiment is related by Mr. *Macquer*, which seems to shew that the *marine acid* is possessed of that very property which has been thought peculiar to nitrous acid and to air, and from which the analogy of these two substances has been chiefly deduced; namely, the property of maintaining combustion. "I introduced " (says that author) a lighted taper into a receiver filled with " vapours of highly-concentrated marine acid, through a tubu" lated aperture. The flame of this taper, which was, before con" tracted, white and almost without smoke, now became long, " pointed, yellow, and smoking, like the flame of burning tur" pentine. But the most remarkable circumstance was, that the " flame subsisted a *much longer time*, than when the taper was in" troduced into the same receiver filled with pure air."

† Dr. *Priestley* has made some experiments to ascertain the proportion

If these earths are capable of being converted into elastic fluids, the resistance they make to this change renders it probable, that the fluids thus formed will be of the most perfect kind, and of the most permanent elasticity. *See* §. 127. The disposition which earths have to unite with phlogiston has been already noticed: but this tendency may exert itself much more powerfully, when it is not counteracted by the mutual cohesion of the particles to each other, by these being reduced to a fluid state. Hence perhaps the singular avidity with which air seizes upon phlogiston in combustion, respiration,

portion of nitrous acid, and of earth contained in the factitious air made from spirit of nitre and earth; but he does not consider them to be decisive. The question is important, but seems difficult of solution. The *Abbe Fontana* maintains, that this factitious air consists of spirit of nitre only, without earth or phlogiston; and he supports his opinion by the following experiments: He converted a given quantity of mercury into red precipitate; and he expelled from this preparation as much air as he could. Then he revived the mercury of the remaining precipitate, and found that the quantity obtained was equal to the quantity of mercury originally employed. Dr. *Priestley* has repeated the experiment; and found that there was a loss of about one eleventh part of the employed mercury: and Mr. *Magellan*, repeating the same experiment, lost about one third of the mercury. It appears then there must have been some error in the *Abbe*'s experiments; but the experiments of Dr. *Priestley*, and of Mr. *Magellan*, are not applied by these gentlemen to ascertain the quantity of earth actually converted into air: neither do I think that they *prove*, that any earth enters into the composition of the air; for in all the productions of air by heat, from earthy substances, the rising air elevates a great deal of earth, and this earth renders the air turbid, gives the appearance of white clouds, and at last subsides. Dr. *Priestley* observes, that the air is transparent while hot, and becomes turbid when cold; which shews that some earth is dissolved in the air, and that cold air not being able to keep dissolved so much [illegible] hot air, part of the earth that was dissolved while th[illegible] hot, is precipitated by cold.

ration, mixture with nitrous gas, and in all the various phlogistic processes, might be attributed to the earthy part which is supposed to enter into the composition of air, if the striking analogy between the effects of air and of nitrous acid, in several of these instances, and also the ready conversion of nitrous acid into factitious air, did not give a greater degree of probability to the opinion, that an acid is the predominant principle in the composition of this fluid. Perhaps acids, while they are converted into air, suffer such a change or decomposition, as to be deprived of the specific properties which distinguish the several kinds of acids from each other, while they retain only the general character of acid; and thus the same compound may be produced from different acids. But of all the acids, the *nitrous* seems to be the most easily convertible to the state of air *.

138. How-

* The opinions which I have here maintained, that most of the known gases consist principally of acid and phlogiston; that the fluid called *calcareous gas*, or *fixed air*, is of an *acid* nature; and that the *nitrous* and *vegetable acids* are convertible into permanently elastic fluids, were suggested in the notes which I added to the first *English* edition of the *Dictionary of Chemistry*, published in 1771. Thus at the article *Fixable Air* are the following passages: "Have not the fluids, separable from alkaline and metallic substances, some analogy with *acids?* Like acids, they readily "*unite* with, and effect the *crystallization* of those (alkaline) substances. As a *weaker* acid is extricated from those substances "by a *stronger*, so is this (fixable) air by all known acids. Are "not the elastic fluids produced by the *deflagration of nitre*; and "by the *combustion* or *alkalization* of *tartar*, and of other *vegetable acid salts*, formed from the *acids* of these substances combined with the *inflammable principle?*"——"A permanently "elastic fluid or fixable air is produced by *deflagration* of *nitrous acid* with any inflammable substance. In this operation the acid "disappears, and an elastic vapour is produced. May we not "thence

138. However imperfect our knowledge of the constitution of the atmosphere may seem, the explanation of the singular properties of the air in maintaining fire and the respiration of animals, in diminishing nitrous gas, in calcining metals, and in being diminished by the various means already described, will be attended with no less difficulty and obscurity. The way to truth, however, must be felt for, when it cannot be seen; and, accordingly, we proceed in our conjectures.

We may perceive, that almost all the chemical changes which happen to bodies, are the result of decompositions, occasioned chiefly by the application of substances, whose attraction to some of the parts of these bodies is stronger than the attraction of the parts to each other. This general observation has been applied to explain the effects of air. It has been supposed that air, or its acid, have a stronger attraction to phlogiston than any other substance; and consequently,

"thence infer, that the *acid* is *converted* by combination with "some other substance, probably with the *inflammable matter*, or "by decomposition of its own substance, into elastic vapour?" *Vol. I. p.* 36. And in a note to the article *Mineral Waters*, it is said; "Does not the *solution of calcareous earths*, by fixable air, "confirm a conjecture concerning the analogy of this vapour with "acids?" *Vol. II. p.* 838. Since the publication of that work, this opinion has been further confirmed by many of the new facts which have been discovered; and the acid quality of the gas, called *Fixed Air*, has been noticed by other later writers. Thus M. *Bergman*, as Dr. *Priestley* informs us, (*Exper. and Observat. vol. I. p.* 31.) is induced, from the effects of this gas on the colour of vegetable flowers, to consider it as an acid, and to call it the *Aerial Acid*. And Mr. *William Bewley* has added an Appendix to Dr. *Priestley*'s second volume, entitled, "Experiments and Observations, tending to prove that Fixed Air is the Vapour of a "*particular* Acid." Mr. *Bewley* distinguishes this fluid by the name of *Mephitic Acid*.

ſequently, that, where any inflammable ignited body is expoſed to air, the phlogiſton leaves this body, and unites with the air.

The *deflagration of nitre* is alſo explained, by ſuppoſing that the nitrous acid poſſeſſes an attraction to the phlogiſton of the inflammable body employed, ſuperior to the attraction of the parts of that body. And the *detonation of fulminating gaſes* ſeems to proceed from the ſudden converſion of acid, together probably with ſome phlogiſton, into gas, as has been already ſuggeſted, §. 123.

The *calcination of metals* is conſidered by chemiſts as a ſlow combuſtion; and the air is ſuppoſed to operate in the ſame manner as in other combuſtions.

139. Various opinions have been formed concerning the mode of operation by which the *reſpiration of air* is neceſſary to the life of breathing animals. See *Haller's Phyſiology*, and *Experiments and Obſervations, vol. III. p. 55.* Of theſe opinions, that which ſeems moſt probable is given by Dr. *Prieſtley*, namely, that reſpiration is a true phlogiſtic proceſs, in which the phlogiſton, with which the animal ſyſtem abounds, is diſcharged from the blood by the lungs, and combined with the reſpired air. And accordingly, the air which has been reſpired, is found to have ſuffered the ſame changes which it does in other phlogiſtic proceſſes, that is, its bulk is diminiſhed, it extinguiſhes flame, and it occaſions a precipitation in lime-water, which ſhews that it contains ſome portion of calcareous gas. He further confirms this opinion, by the remarkable changes which blood undergoes by expoſure to air. Mr. *Hewſon* had diſcovered that blood received a florid colour from air during its paſſage through the lungs. See *Mr. Hewſon's Experimental*

Inquiry

Inquiry into the Properties of Blood. M. *Cygna* had alſo ſhewn, that a florid colour could be given to the under black part of the coagulum of blood, by expoſing this part to air; and that the upper ſurface of blood was black in vacuo. *Miſcell. Taurin. I.* 73. To theſe obſervations Dr. *Prieſtley* has added others equally important. He found that the change produced by air on the colour of blood, was not prevented by the interpoſition of a bladder, nor of the ſerum of blood; that blood was rendered florid in a more remarkable degree, by pure factitious air; that blood was rendered black by inflammable, nitrous, and calcareous gaſes, and alſo by phlogiſticated air; that by expoſing blood to air, this fluid was thereby phlogiſticated; and that by expoſing blood to the other gaſes, theſe ſuffered conſiderable changes, the bulk of the *nitrous gas* being thereby leſſened, and its property of being condenſed by mixture with air being conſiderably diminiſhed; the *inflammable gas* being thereby made to approach ſo far to the ſtate of air, as to be capable of effecting a conſiderable diminution of nitrous gas; and *phlogiſticated air* being alſo rendered capable of producing ſome diminution of nitrous gas. *See Exper. and Obſerv. vol. III. p.* 55, *&c.*

140. Dr. *Prieſtley* alſo conſiders the effects of *mixing nitrous gas with air* as a phlogiſtic proceſs, in which the air deprives the gas of its phlogiſton; and he ſuppoſes, that, in all thoſe inſtances where air is diminiſhed by liver of ſulphur and other phlogiſtic ſubſtances, the air attracts and combines with the phlogiſton of theſe ſubſtances, and becomes thereby *phlogiſticated.*

If it ſhould be aſked why the phlogiſton of inflammable bodies cannot be ſeparated without heat, and

 even

even ignition; whereas this phlogiston may be separated from nitrous gas, from the blood in respiration, from liver of sulphur, and other phlogistic bodies, merely by contact of air; may we not answer, that, in the latter instances, the phlogiston is but slightly attached, and easily separated; whereas, in inflammable bodies, it is so intimately combined, that it cannot be separated, till the parts of these bodies have been thrown into violent agitation by heat, their cohesion diminished, the volatility and activity of the phlogiston encreased, and its combination with air thus facilitated? And may not the intense heat, flame, and other effects of burning bodies, proceed from the agitation excited among their most active parts, from the violence with which they are torn asunder from each other, and from the rapidity with which the minute and elastic particles of air and phlogiston rush into union? For, in what does *heat* consist, but in the exceedingly quick vibrations of the particles of burning bodies; or *light*, but in the extreme rapidity and force with which the most active particles are thrown from the surfaces of these bodies?

If it should be asked why air, or, at least, why the factitious air, which is produced from nitrous acid, should take phlogiston from nitrous gas, which is also formed principally from that acid; may we not answer, that, although each of these fluids contain, in their composition, nitrous acid, yet they are very different combinations? For, if the nitrous gas contain, as has been above conjectured, a considerable portion of water in its composition, its attraction to phlogiston will be thereby so weakened, that air may be able to deprive it of this essential part to its elastic state; while the other parts in the composition

of

of this nitrous gas, the acid and the water, ſhall be condenſed and reduced to the ſtate of liquid nitrous acid.

M. *Lavoiſier* is of opinion, that nitrous acid is not a conſtituent part of air, but that air is a conſtituent part of nitrous acid, and that the nitrous acid, formed upon mixing nitrous gas with air, is compoſed of both theſe fluids united together, and therefore that the nitrous gas does not contain the nitrous acid, but only a ſubſtance proper to form it, by combining with air.

Whence proceeds the heat that is obſerved upon the mixture of nitrous gas with air? May it not be a neceſſary conſequence of the condenſation which inſtantly happens upon the mixture of theſe two fluids? For, is it not an univerſal rule, that cold is produced by the expanſion of bodies into a rarer ſtate; and heat by their condenſation? Hence the cold produced during the evaporation of fluids, and during the rarefaction of air, by means of the air-pump; and hence the heat which is communicated by vapours during their condenſation, which has been obſerved to be much greater than can be communicated by an equal quantity of any concrete matter heated to the ſame temperature.

Hence alſo the heat that is obſerved to accompany *fogs*, which are nothing but condenſed vapours. Are not the other diminutions of air, and condenſations of elaſtic fluids, alſo accompanied with heat *?

 141. The

* Heat is generally produced, while two ſubſtances combine, and their combination is accompanied with condenſation; that is, when the new compound occupies leſs ſpace than its conſtituent parts did before their union. But the combination of phlogiſton with air is always accompanied with condenſation, as appears from the diminution of the air in all phlogiſtic proceſſes. May not then the heat produced by the union of air with phlogiſton in the lungs of animals, during their reſpiration, be one cauſe of *animal heat*?

141. The *alteration produced in air*, by the *phlogistic processes*, is very remarkable. Air, by this phlogistication, seems to be converted into two distinct compounds, *phlogisticated air*, and *calcareous gas*, both which are very different in their properties from air. While the phlogiston unites with that part of air to which it seems to be most disposed, and forms with it the new compound *phlogisticated air*; the other parts of air, less disposed to unite with phlogiston, are precipitated, forming another compound, which, from its property of occasioning a precipitation in lime-water, appears to be the fluid described under the name of *calcareous gas*. We might suspect that this gas proceeded from the burning body, or substances, on which the air exerts its action, if we did not know that the same gas was produced when air is decomposed by electrical sparks passing through it.

Whether this gas be precipitated from air; or be a compound formed from the decomposed parts of the burning substance; or, lastly, whether some gas of this kind may not proceed from both these causes; we nevertheless can scarcely doubt that some part of the air is separated, fixed and combined with the burning substance. This opinion is confirmed by the following experiment of M. *Lavoisier*.

He burnt some phosphorus under a bell, the inner surface of which was moistened with distilled water. The quantity of phosphorus employed was 186 grains. Of this quantity thirty-two grains remained unconsumed; and therefore 154 grains were actually burnt. The vapours of the phosphoric acid being condensed by means of the water, with which the bell was moistened, were collected and weighed in a narrow-necked vessel; by which means he found, that the weight of the

the acid liquor exceeded the weight of an equal bulk of distilled water 243½ grains, which was 89½ grains more than the quantity of phosphorus consumed. These 89½ grains could not be water attracted by the phosphoric acid, for the specific gravity of the liquor could not have been thereby encreased; and he therefore infers, that this accession of matter must have proceeded from some part of the air absorbed during the combustion.

In one instance however of air being diminished, no calcareous gas is precipitated, namely, the calcination of metals, which is considered as a combustion. Dr. *Priestley* alledges ingeniously, that the gas is formed in this as in other instances, but is absorbed by the calcining metal, and that this is the part of air, by the absorption of which, metals acquire weight during their calcination. This absorption of gas would be rendered more probable, by the consideration that, during the reduction of metallic calxes, a quantity of this calcareous gas is obtained, if the addition of inflammable matter necessary for such reduction did not leave some suspicion, that this matter *might* possibly furnish the gas thus produced.

142. The weight gained by metals during their calcination, is a fact too extraordinary not to have employed the ingenuity of philosophers in explaining its cause. *Boyle* and *Lemery* have attributed this encrease of weight to the particles of *fire* or *flame*, which they supposed were absorbed by metals during their calcination. *Charas*, a chemist cotemporary with *Lemery*, ascribes this effect to the *acid* of the *wood*, or of the *coal* employed in the calcination.

M. *Venel* and M. *Morveau* maintain, that this encrease of weight is not occasioned by the addition of

any

any ſubſtance to the metallic matter, but by *depriving* this matter of its *phlogiſton*. For theſe philoſophers pretend, that phlogiſton is endowed with a power contrary to that of gravitation, namely, of receding from the center of the earth, and thereby of rendering bodies, of which it makes a part, lighter than they otherwiſe would be. It is evident that a doctrine attributing to this phlogiſton (a ſubſtance which is not the object of any of our ſenſes) a property directly contrary to *gravitation*, which is an undoubted property of all thoſe ſubſtances that are the objects of our ſenſes, requires to be ſupported by very deciſive experiments, and unequivocal arguments.

As the air is diminiſhed by the calcination of metals, while theſe, at the ſame time, gain an acceſſion of weight, we cannot heſitate to aſcribe this acceſſion to the abſorption of air, or of ſome part of it, as has been already obſerved. *See* §. 13. *and note ſubjoined.*

Some inſtances have been mentioned (§. 26.) of metallic calxes yielding pure air by means of heat. That this pure air has been abſorbed from the atmoſphere, ſeems highly probable; and as the preparation of minium and of calcined mercury, requires a longer expoſure to the action of fire and of air, than that of other calxes, theſe metallic matters may perhaps be deprived more perfectly of ſuperabundant phlogiſton, or may abſorb a larger quantity of air than the calxes of other metals. Neverthelefs, we can ſcarcely conſider the pure air thus abſorbed by minium and calcined mercury as the ſubſtance eſſential to them as calxes, and to which their additional weight is principally owing; for minium, after it has been deprived by heat of all its pure air, ſtill retains its calciform ſtate, and is heavier than the lead from which it was produced *.

143. Are

* The calx of mercury may indeed be revived or reduced by the heat of a furnace in cloſe glaſs veſſels without any addition of inflammable matter. And thus the ſame operation ſeems to effect the reduction of this calx, and the expulſion of air from it; which would ſeem to ſhew that its calciform ſtate is occaſioned merely by the preſence of this air; and accordingly Mr. *Bayen* has inferred from

143. Are not *metallic precipitates*, combinations of acid and metallic earth? And is not the revival of these precipitates effected by the combination of phlogiston with the adhering acid, forming a gas; and with the metallic earth, forming the revived metal?

144. The production of air, by water decomposing or absorbing part of the calcareous and other gases, §. 25; the precipitation of calcareous gas from air, by the several phlogistic processes; and the several instances above mentioned of nitrous, inflammable, and other gases being so altered by various substances, as to lose their specific characters, and to approach to that of air; seem to shew that these fluids contain in their composition the same elements, and that their differences arise principally from the different proportions of these elements, which take place in different modes of combination.

145. We may easily perceive that many important questions remain to be ascertained on the subject of this Treatise: And although we are highly indebted to the sagacity and industry of those philosophers who have led us to our present state of knowledge, yet much more remains undiscovered to excite and recompense the zeal of future labourers in this fertile and still new field of science.

When we shall be able more fully to ascertain the con-

from this fact, that calxes may be revived without addition of phlogiston, and that the theory of *Stahl*, which makes the calcination of metals to consist in the depriving them of phlogiston, is thereby overthrown. But a conclusion from a single fact, subversive of a theory founded on the general course of appearances, ought to be very cautiously admitted. For it may be doubted, whether the very small quantity of phlogiston, that may be necessary to the revival of the calx of mercury, may not pass through glass vessels softened by heat. Although mercury may not be capable of so perfect a calcination as the imperfect metals, nevertheless it is so far changed by the combined action of air and fire, as to lose not only its metallic appearance, but also, like other volatile metallic substances, to be rendered considerably more fixed when exposed to heat. It is even said to sustain a *fusion* or *vitrification*, like other metallic calxes, when exposed to the pure heat of a burning glass. *See a note of Dr. Lewis, in his translation of Newman's Chemistry, vol. I. p. 134.*

conſtituent parts of the ſeveral gaſes, the proportions of theſe parts to each other, and the circumſtances neceſſary to each mode of combination; we may then perhaps be enabled to diſcover the various compoſitions, decompoſitions and changes, which theſe fluids ſuffer in many natural operations. We may alſo perhaps be enabled to trace the ſame ſubſtance through a great variety of forms. Thus we may obſerve the oily concrete acid of vegetables undergoing its various changes through the different periods of vegetable life from ſeed to maturity; till, by the vinous or other fermentations, or by fire, it be diſengaged from the more fixed earthy matters, which were united with it, be more perfectly combined with phlogiſton, and aſſume an elaſtic ſtate. In this ſtate, it may mix with the atmoſphere, and conduce perhaps to ſome of the ſtriking phenomena which happen there; or, be abſorbed by the humid vapours floating in the air, and again conveyed by theſe vapours into the organs of vegetables: thus paſſing along in that perpetual circulation of matter, which makes the Proteus-like face of Nature, an ever-varying, pleaſing picture. Or, if we may be indulged a bolder imagination, where our yet infant experience cannot reach; may not theſe fluids, while raiſed into their elaſtic ſtate, undergo further changes? May they not be decompoſed and rarefied into the moſt active elements, and while they advance in this progreſſion of ſubtilization, may they not acquire new properties and powers, unknown in denſe matter? May they not then pervade all bodies, and become that highly elaſtic *ethereal medium*, which, as *Sir Iſaac Newton* † conjectures, may be the proximate cauſe of *coheſion*; of *gravitation*; of *electrical attraction* and *repulſion*; of the *refraction*, *reflection*, *inflexion*, and the *heat* of the *rays* of *light*; of *animal motion*, and of *animal ſenſation*?

† *Optics*, *Quer.* 19, 20, 21, 22, 23, 24, and *Principia Mathem.* §. *ultim.*

THE END.